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JOHN F. KENNEDY
SPACE CENTER

APOLLO/SATURN V
CONSOLIDATED INSTRUMENTATION PLAN
FOR AS-510
(APOLLO 15)

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K-V-059/10

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FOR AS-510

(APOLLO 15)

June 11, 1971

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LIST OF ABBREVIATIONS

ACE	Acceptance Checkout Equipment
ACQ	Acquisition
AFETR	Air Force Eastern Test Range
ALDS	Apollo Launch Data System
ALSEP	Apollo Lunar Surface Experiment Package
ARIA	Apollo Range Instrumentation Aircraft
AS	Apollo Saturn
BDA	Bermuda
BH	Blockhouse
c	centi (10^{-2})
C-Band	5000 to 6500 MHz/3900 to 6200 MHz
CADDAC	Central Analogue Data Distribution and Computer System
CBW	Constant Bandwidth
CCATS	Communications, Command and Telemetry System
CCS	Command and Communications System
CIF	Central Instrumentation Facility
CKAFS	Cape Kennedy Air Force Station
C	Center Line
CM	Command Module
CRT	Cathode Ray Tube
CSM	Command Service Module
DCU	Digital Control Unit

LIST OF ABBREVIATIONS (Continued)

DDAS	Digital Data Acquisition System
deg	Degree
EASEP	Early Apollo Scientific Experiments Package
EBW	Exploding Bridge Wire
ETR	Eastern Test Range
WE	AFETR Staff Meteorologist
EVA	Extravehicular Activity
FCA	Frequency Control and Analysis
FM	Frequency Modulation
GBI	Grand Bahama Island (AFETR Station)
GBM	Grand Bahama Island (NASA Station)
GCTA	Ground Commanded Television Assembly
G.E.T.	Ground Elapsed Time
GH_2	Hydrogen Gas
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center (Greenbelt, Md.)
GTK	Grand Turk Island
hr	Hour
Hz	Hertz (Cycle per second)
IGOR	Intercept Ground Optical Recorder
IP	Impact Prediction
IU	Instrument Unit (Saturn Vehicle)
k	Kilo (10^3)
KSC	Kennedy Space Center

LIST OF ABBREVIATIONS
(Continued)

LC	Launch Complex
LCC	Launch Control Center
LCRU	Lunar Communications Relay Unit
LES	Launch Escape System
LH_2	Liquid Hydrogen
LIEF	Launch Information Exchange Facility
LM	Lunar Module
LOS	Loss of Signal
LOX	Liquid Oxygen
LRV	Lunar Roving Vehicle
LTDS	Launch Trajectory Data Subsystem
LV	Launch Vehicle
LVDA	Launch Vehicle Data Adapter
LVDC	Launch Vehicle Digital Computer
m	Milli (10^{-3})
m	Meter
M	Mega (10^6)
MCC-H	Mission Control Center-Houston
METS	Meteorological System
MIL	MILA USB
MILA	Merritt Island Launch Area
min.	Minute
MITTS	Mobile Igor Tracking Telescope System
MPC	Meteorological Prediction Center
MRTS	Meteorological Real-Time System

LIST OF ABBREVIATIONS
(Continued)

MSC	Manned Spacecraft Center (Houston, Texas)
MSFC	Marshall Space Flight Center (Huntsville, Alabama)
MSOB	Manned Spacecraft Operations Building
NAR	North American Rockwell
NASA	National Aeronautics and Space Administration
n.mi.	Nautical Mile
NO.	Number
OD	Operations Directive
OTV	Operational Television System
PAFB	Patrick Air Force Base
PAMS	Pad Abort Measuring System
PCM	Pulse Code Modulation
P&FS	Particles and Fields Subsatellite
PM	Phase Modulation
PRN	Pseudo Random Noise
PSRD	Program Support Requirements Document
PTS	Points
Q	Dynamic Pressure
rf	Radio Frequency
ROTI	Recording Optical Tracking Instrument
RS	Rawinsonde
RSO	Range Safety Officer
RTCC	Real-Time Computer Complex (Houston)
RTCS	Real-Time Computer System (ETR)

LIST OF ABBREVIATIONS
(Continued)

S-Band	1550 to 5200 MHz
SC	Spacecraft
SD	Support Document
sec	Second
SIM	Scientific Instrument Module
SLA	Spacecraft LM Adapter
SMG	Spaceflight Meteorology Group (U. S. Weather Bureau)
SRS	Secure Range Safety
STA	Station
TDDS	Television Data Display System
TEL	Telemetry
TLM	Telemetry
TTY	Teletype Communications
TV	Television
TW	Thermal Wire
USB	Unified S-Band
USNS	United States Naval Ship
UV	Ultra Violet
VAB	Vertical Assembly Building
VIB	Vertical Integration Building
VHF	Very High Frequency (30-300 MHz)
vs	Versus
WINDS	Weather Information and Display System
WS	Windsonde
X-Band	5200 to 10,900 MHz

SECTION I

INTRODUCTION

This report presents the consolidated instrumentation plan for employing optical and electronic data acquisition systems to monitor the performance and trajectory of Apollo Saturn V vehicle 510 during the launch phase of the mission (prelaunch, liftoff to insertion). Telemetry, optical, and electronic tracking equipment on board the vehicle and data acquisition systems monitoring the flight are discussed. Flight Safety instrumentation, vehicle data transmission systems, and geophysical instrumentation are also described.

This plan reflects the general instrumentation requirements set forth in NASA PSRD No. 40000 for Apollo Saturn V, and is not intended to conflict with or supersede that document.

The information presented in this document reflects planning concepts developed prior to June 11, 1971.

SECTION II
MISSION PROFILE

2.1 APOLLO 15 VEHICLE CONFIGURATION (see Figure 2-1)

2.1.1 SATURN V LAUNCH VEHICLE 510

2.1.1.1 S-IC 510. The S-IC stage carries the following instrumentation: Two telemetry links and a dual command/destruct system.

2.1.1.2 S-II 510. The S-II stage carries the following instrumentation: Three telemetry links and a dual command/destruct system.

2.1.1.3 S-IVB 510. The S-IVB stage carries the following instrumentation: One telemetry link and a dual command/destruct system.

2.1.1.4 IU 510. The IU carries the following instrumentation: Two VHF telemetry links, two C-band radar transponders, and the CCS transponder (S-band).

2.1.2 APOLLO SPACECRAFT

2.1.2.1 CSM 112. The CSM carries the following instrumentation: Unified S-band equipment, X-band rendezvous transponder, a dual VHF/AM transceiver, a VHF recovery beacon, a VHF survival beacon-transceiver, a beacon light, a swimmer umbilical, and dye marker.

The Scientific Instrument Module (SIM) equipment aboard the CSM for lunar orbit experiments will include: Gamma-Ray Spectrometer, X-Ray Flourescence Detector, Alpha Particle Spectrometer, three-inch Mapping Camera, twenty-four-inch Panoramic Camera, Laser Altimeter, and Mass Spectrometer. The Particles and Fields Subsatellite (P&FS) is stowed in the SIM and contains an S-band transponder, magnetometer, and particle measurement sensor.

2.1.2.2 LM-10. The Lunar Module carries the following instrumentation: Unified S-band equipment, X-band rendezvous radar, X-band landing radar, two VHF/AM transceivers. The ALSEP Array A-2 and Lunar Rover Vehicle (LRV) equipment will be off-loaded on the lunar surface.

2.2 MISSION DESCRIPTION

The AS-510 will fly the "J-1" mission.

2.2.1 MISSION "J-1." The OMSF objectives are:

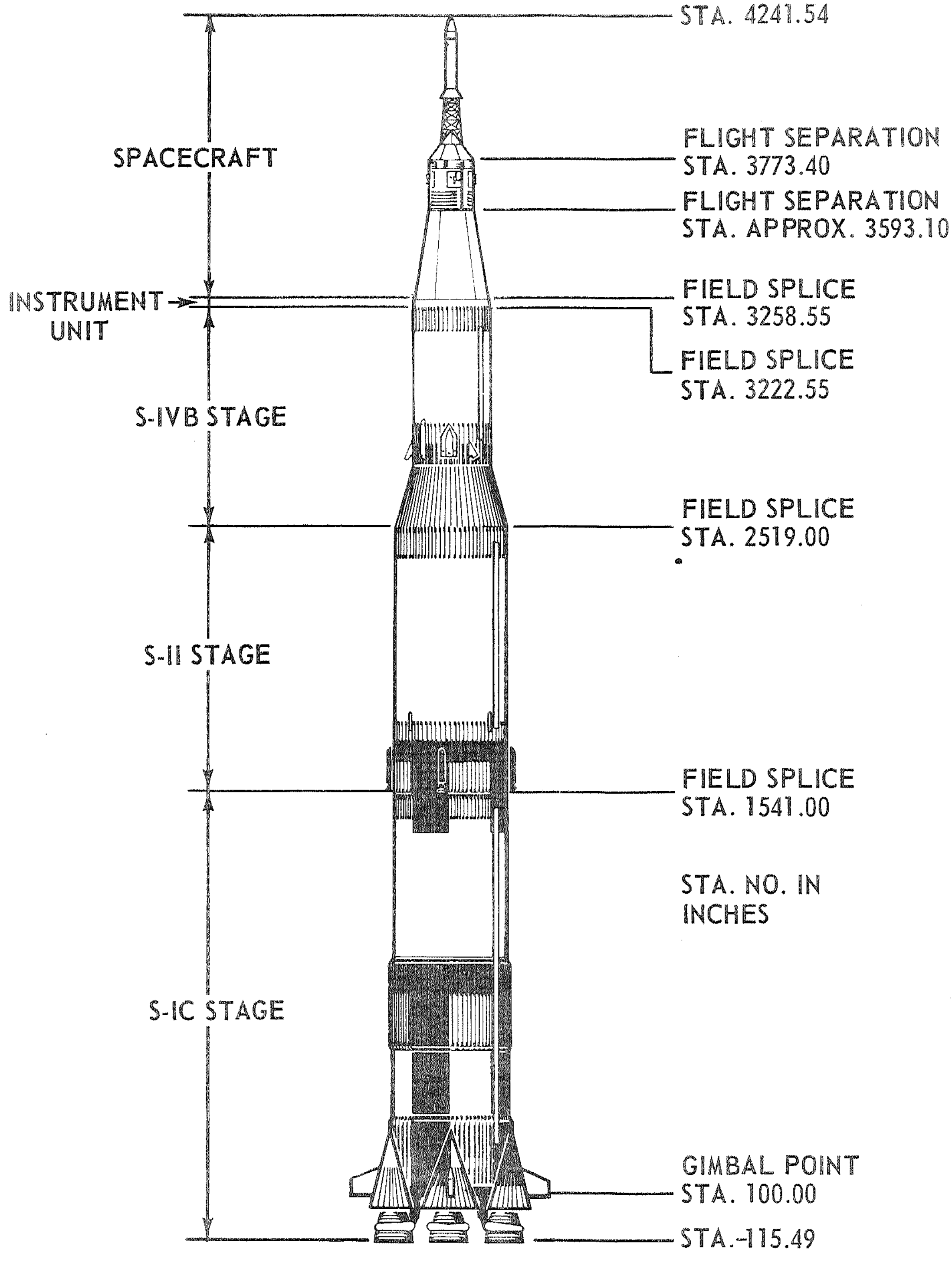


FIGURE 2-1. APOLLO 15 VEHICLE CONFIGURATION

Perform selenological inspection, survey and sampling of materials and surface features in a preselected area of the Hadley-Apennine region.

Emplace and activate surface experiments.

Evaluate the capability of the Apollo equipment to provide extended lunar surface stay time, increased EVA operations, and surface mobility.

Conduct inflight experiments and photographic tasks from lunar orbit.

a. Launch Pad - LC-39A.

b. Flight Azimuth - Variable 80.088° to 100° (0°N) depending upon time within the window.

c. Launch Opportunities - July 26, 1971 (prime) and July 27, 1971.

d. Launch Window (Eastern Daylight Time):

July 26, 1971 - 0934 to ~~1109~~ 1210 hours.

Window Duration:

July 26, 1971 - 2 hrs. 36 min.

e. Injection Opportunities - Pacific translunar opportunities on the second and third orbits are to be utilized for translunar injection (TLI).

f. Trajectory - Table 2.1 is a summary of the launch phase mission events for an 80.088° flight azimuth. The S-IVB/IU/CSM/LM is injected into a nearly circular 90 nautical-mile orbit with a period of 87.8 minutes. On the second and third orbits after successful checkout of S-IVB/IU/CSM/LM, the S-IVB will be restarted over the Pacific Ocean to place the S-IVB/IU/CSM/LM into translunar trajectory. The S-IVB will then execute maneuvers to assure spacecraft (SC) clearance and result in S-IVB/IU lunar impact. Table 2.2 lists launch vehicle orbital events.

At approximately T+80 hours, the CSM/LM brakes into lunar orbit. After lunar orbit is achieved, the LM will separate from the CSM and land on the lunar surface in the Hadley-Apennine area. The astronauts will perform up to three lunar excursions including use of the Lunar Roving Vehicle (LRV). An experiment package, ALSEP Array A-2, will be deployed on the lunar surface. In addition, a wide range of experiments will be conducted from the CSM while in lunar orbit, including a Particles and Fields Subsatellite (P&FS) to be ejected from the CSM. After transearth

Table 2.1 LAUNCH PHASE MISSION EVENTS (80.088° F.A.)

EVENT	TIME FROM FIRST MOTION (sec)	EARTH-FIXED VELOCITY (m/sec)	ALTITUDE (km)	GROUND RANGE (km)
First Motion	0.0	0.0	0.0	0.0
Initiate Tilt	11.4	28.8	0.2	0.0
Max. Q	80.0	489.2	13.1	5.0
S-IC O.E.C.O.	158.8	2372.3	68.6	89.5
S-II Eng. Start	162.2	2370.7	72.0	96.8
IGM Enable	200.4	2524.6	105.7	182.2
S-II C.E.C.O.	458.8	5269.5	178.4	1098.1
S-II Eng. C.O.	553.8	6564.4	175.0	1642.5
S-IVB Eng. 90% Thr.	560.4	6572.8	175.0	1684.7
S-IVB First Guidance C.O.	704.3	7388.0	171.8	2660.6
Parking Orbit Insertion	714.3	7389.5	171.8	2732.5

Table 2.2 LAUNCH VEHICLE ORBITAL EVENTS
(First TLI Opportunity)

EVENT	G.E.T. Hr.	G.E.T. Min.
S-IVB Reignition	2	50
S-IVB 2nd Guidance C.O.	2	56
S-IVB Translunar Injection	2	56
S-IVB H_2 Continuous Vent Off	2	58

injection (TET), an EVA will be accomplished to retrieve experiment film cassettes from the Scientific Instrument Module (SIM). The coast period will not exceed 110 hours. Reentry will be over the Pacific, and recovery will be on or near the Mid-Pacific recovery line.

SECTION III
ONBOARD EQUIPMENT

3.1 ELECTRONIC TRAJECTORY DATA ACQUISITION EQUIPMENT

The electronic trajectory data acquisition equipment carried on AS-510 is listed in Table 3.1. Locations of the onboard antennas are shown in Figures 3-2, 3-3, and 3-4.

TABLE 3.1 ONBOARD ELECTRONIC TRACKING DATA ACQUISITION EQUIPMENT

SYSTEM	FREQUENCIES (MHz)		LOCATION	REMARKS
	Receive	Transmit		
C-Band Transponders	5690	5765	IU	The IU contains two transponders. Each accepts a double pulse signal, with 8 microseconds between pulses, and transmits a single pulse reply. Each transponder radiates through its own antenna system. The transponders will operate simultaneously.
Command & Communication System (CCS)	2101.8	2282.5	IU	The CCS is a composite system designed to: Transmit and receive phase-modulated PRN Range Code; receive command/update functions; and transmit PCM/PM telemetry. The system may be shut down by ground command during LM USB operation.

(Continued on next page)

TABLE 3.1 ONBOARD ELECTRONIC TRACKING DATA ACQUISITION EQUIPMENT (Cont'd)

SYSTEM	FREQUENCIES (MHz)		LOCATION	REMARKS
	Receive	Transmit		
USB	2106.4	2272.5 2287.5	CSM	A composite system designed to transmit and receive voice communication and phase-modulated ranging code; receive updata/commands; and transmit PCM telemetry, television and tape playback (CSM only) of telemetry and voice.
	2101.8	2282.5	LM	
Rendez-vous Radar	9792.0	9832.8	LM	Designed to facilitate rendezvous of LM and CSM in lunar orbit.
Rendez-vous Radar Tran-sponder	9832.8	9792.0	CSM	Designed for use with LM Rendezvous Radar.
Landing Radar		10510(Vel) 9580(Alt)	LM	Designed to provide the LM altitude and velocity data on lunar descent.

3.2 OPTICAL DATA ACQUISITION EQUIPMENT

3.2.1 OPTICAL TARGETS. Optical targets, painted on the vehicle to aid in the determination of first motion and vertical motion, are shown in Figure 3-1.

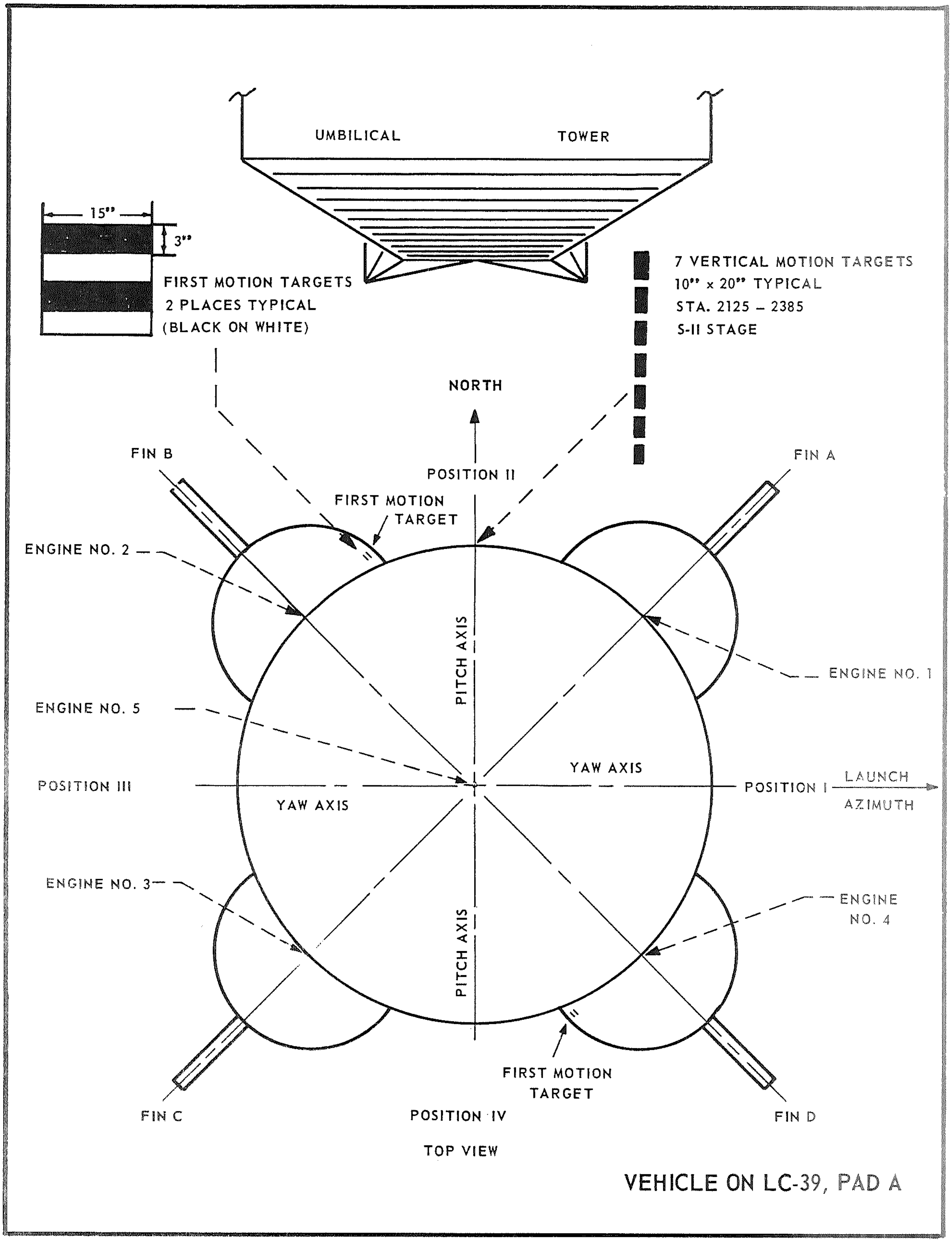


Figure 3-1. Apollo/Saturn V Orientation and Camera Target Locations

3.3 TELEVISION SYSTEMS

3.3.1 COMMAND MODULE TELEVISION SYSTEM. A color television camera will provide real-time video data via the USB system. A twelve-foot cable allows portable use of the camera. Two semi-stationary locations will allow instrument panel viewing, and a third, a front viewing of the crew. The downlink frequency is 2272.5 MHz.

3.3.2 LUNAR MODULE TELEVISION SYSTEM. A color camera is planned. The TV camera will provide real-time video to earth via the LM USB system. A one-hundred-foot cable will permit use of the camera on the lunar surface. The color camera is provided with a zoom lens.

The LM USB downlink frequency is 2282.5 MHz. The LCRU antenna or the LM S-band steerable antenna may be utilized for USB operations during lunar stay.

3.3.3 LUNAR COMMUNICATIONS RELAY UNIT (LCRU)/GROUND COMMANDED TELEVISION ASSEMBLY (GCTA). The system is composed of two S-band subsystems and a VHF subsystem. TV/data/voice from the Lunar Roving Vehicle (LRV) via the LCRU to the MSFN during lunar EVA is the prime mode of operation. The LRV TV system can be remotely controlled from the MSFN via the GCTA. LM lift-off will be televised for the first time via the LRV/LCRU/GCTA. The uplink and downlink S-band frequencies are 2106.4 MHz (same as LM) and 2265.5 MHz, respectively. The VHF transmit/receive frequencies are 259.7 and 296.8 MHz.

3.4 TELEMETRY SYSTEMS

The telemetry links carried on the AS-510 vehicle are listed in Table 3.2.

TABLE 3.2 TELEMETRY SYSTEMS

LINK NO.	FREQUENCY (MHz)	MODULATION	TRANSMITTED POWER (Watts)	LOCATION	REMARKS
AF-1 AP-1	256.2 244.3	FM/FM PCM/FM	20 15	S-IC	
BF-1 BF-2 BP-1	241.5 234.0 248.6	FM/FM FM/FM PCM/FM	20 20 15	S-II	
CP-1	258.5	PCM/FM	15	S-IVB	
DP-1 DF-1 DP-1B (CCS)	245.3 250.7 2282.5	PCM/FM FM/FM PCM/PM	15 20 15	IU	CCS Down-link parallel to DP-1
LM-PCM	2282.5	USB FM or PM	0.75 or 20	LM	This frequency shared with CCS downlink
ALSEP Array A-2	2278.0	PCM/PM		LM/Lunar Surface	ALSEP uplink frequency 2119 MHz
LCRU	2265.5	USB FM or PM	6 or 8	LM/Lunar Surface/ LRV	Uplink frequency 2106.4 MHz
CSM-P/B CSM-R/T	2272.5 2287.5	USB FM Mode USB PM Mode	0.25,5,20 5 or 20	CSM CSM	
P&FS	2282.5	USB PM Mode		CSM/ Lunar Orbit	Uplink frequency 2101.8 MHz

3.5 TAPE RECORDERS

3.5.1 CSM TAPE RECORDER. The CSM carries one tape recorder. The Operational Recorder provides recording and playback of telemetry and voice data. Playback is accomplished via the USB system. The CSM recorder may be utilized to process LM and EVA voice/data if required. The LM has voice recorder capability.

3.6 RADIO COMMAND CONTROL SYSTEMS

3.6.1 LAUNCH VEHICLE RANGE SAFETY DIGITAL COMMAND/DESTRUCT SYSTEM. The S-IC, S-II, and S-IVB stages carry dual independent Secure Range Safety (SRS) command systems operating at 450 MHz. Three commands may be transmitted through the SRS system; they are:

a. ARM/FUEL CUTOFF - Terminates thrust and arms the EBW firing unit charge circuits.

b. DESTRUCT - Firing of the EBW.

c. SAFE - Disconnects the command decoding equipment from the battery.

3.6.2. SPACE VEHICLE COMMAND/CONTROL SYSTEMS

3.6.2.1 Command and Communications System (CCS). The IU stage carries the CCS which provides guidance system data update, guidance system closed-loop testing initiation, and other vehicle command data. The IU Command System access to these functions is through the Launch Vehicle Guidance Digital Computer (LVDC). The CCS uplink operates at 2101.8 MHz and the downlink at 2282.5 MHz.

3.6.2.2 CSM USB Command System. The CSM USB command system, operating on a frequency 2106.4 MHz, provides uplink capability for voice, data, commands, and ranging code.

3.6.2.3 LM Updata Link. The LM USB system provides an updata link on 2101.8 MHz with capability for voice, data, commands, and ranging codes. The updata link of the CCS system on the IU also operates at this frequency.

3.6.2.4 LCRU Updata Link. The Dual S-band systems on the LCRU provide an uplink for voice and data/commands at 2106.4 MHz.

3.6.2.5 P&FS Updata Link. The S-band system provides uplink for digital commands at 2101.8 MHz.

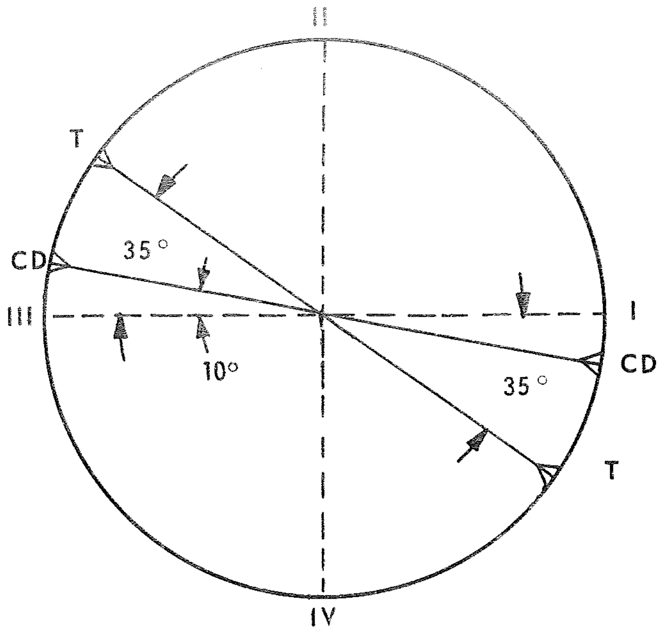
3.7 LUNAR EXPERIMENT EQUIPMENT

3.7.1 ALSEP ARRAY A-2. The ALSEP will be off-loaded on the lunar surface. Seven experiments will provide data on passive seismic phenomena, surface magnetism, solar wind, heat flow, laser ranging, lunar dust, and lunar ion/atmosphere environment. The uplink and downlink frequencies are 2119 and 2278.0 MHz, respectively. MSFN S-band sites will support the experiment.

3.7.2 LUNAR ROVING VEHICLE. The LRV contains a dual S-band system, and a single VHF system provides communications during EVA between the astronauts and the MSFN when beyond LM VHF range.

3.7.3 SIM EQUIPMENT. The Scientific Instrument Module on the CSM contains lunar orbit experiments, including the Particles and Fields Subsatellite. Data from thirteen experiments will provide a wide range of lunar survey data. Data retrieval will be by film, CSM S-band telemetry, and P&FS S-band telemetry. The MSFN sites will support the CSM and P&FS S-band telemetry.

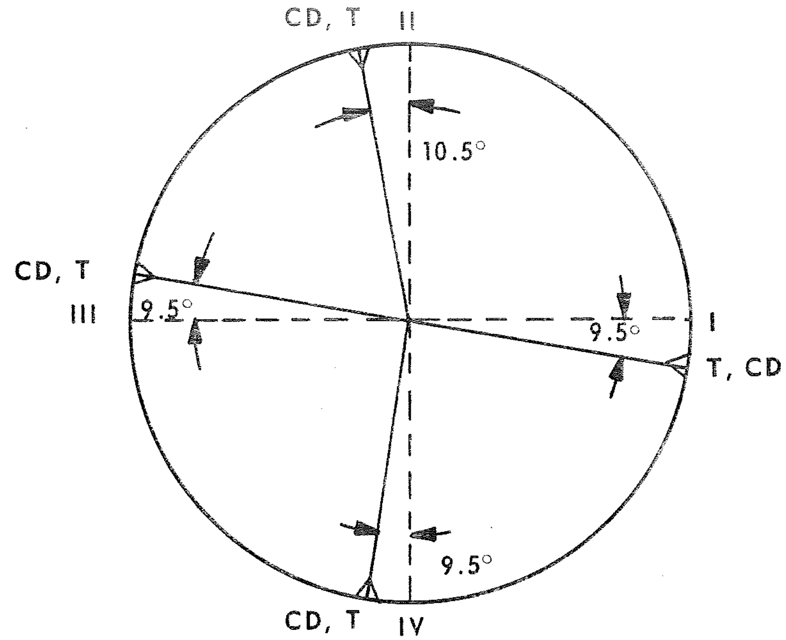
3.7.4 EVA EQUIPMENT. The EVA suits contain VHF/AM and VHF/FM equipment to provide lunar surface voice/data communication.



S-IC STAGE

T – TELEMETRY ANTENNAS – STA. 1459.00

CD – COMMAND DESTRUCT ANTENNAS – STA. 1503.20

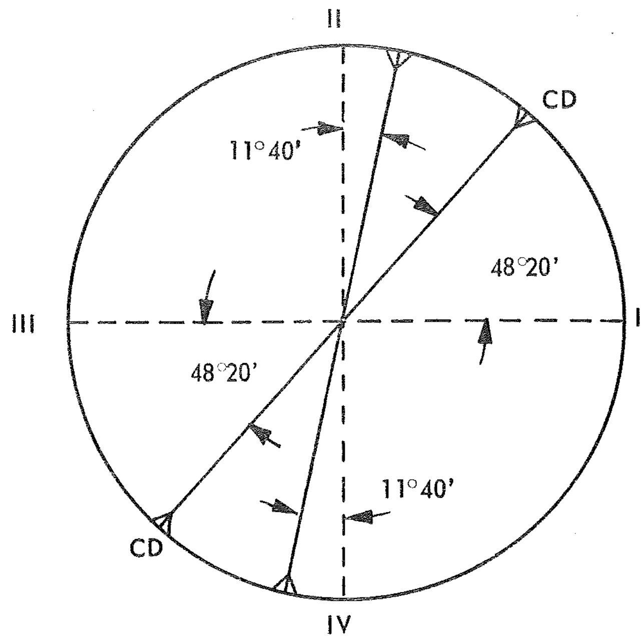


S-II STAGE

T – TELEMETRY ANTENNAS – STA. 2465.00

CD – COMMAND DESTRUCT ANTENNAS – STA. 2494.00

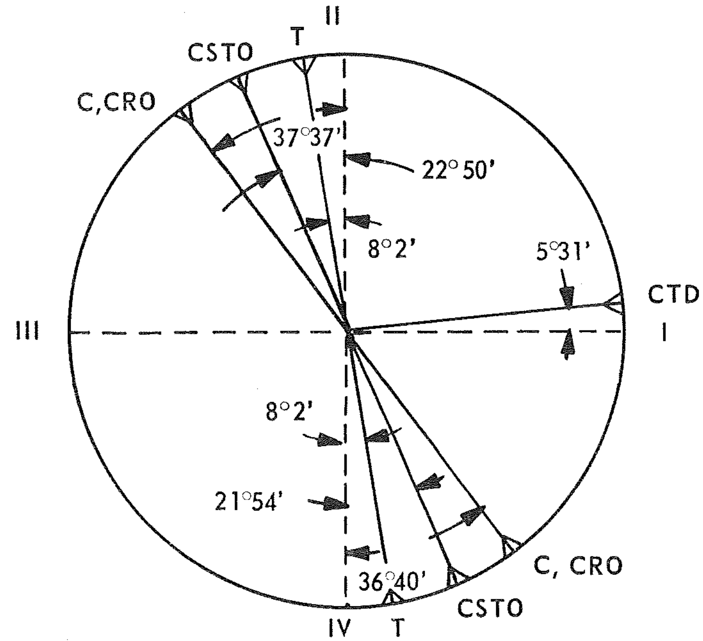
Figure 3-2. Location of S-IC and S-II Onboard Antennas



S-IVB STAGE

T – TELEMETRY ANTENNAS – STA. 3193.55

CD – COMMAND DESTRUCT ANTENNAS – STA. 3193.55



INSTRUMENT UNIT (IU)

C-C – BAND RADAR ANTENNAS – STA. 3234.82

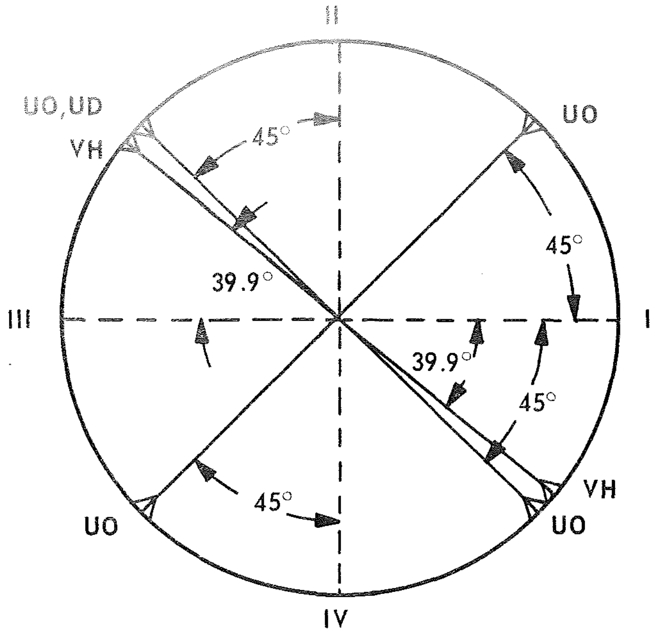
CRO – CCS RECEIVING OMNI ANTENNAS – STA. 3251.98

CSTO – CCS TRANSMITTING OMNI ANTENNAS -- STA. 3251.73

CTD – CCS TRANSMITTING DIRECTIONAL ANTENNA – STA. 3246.50

T – VHF TELEMETRY

Figure 3-3. Location of S-IVB and IU Onboard Antennas



COMMAND SERVICE MODULE

UD – USB, HIGH GAIN ANTENNA – STA. 3593

UO – USB, OMNI ANTENNAS – STA. 3776

VH – VHF/AM ANTENNAS – STA. 3674

VHF RECOVERY ANTENNAS – TIP OF CM(2)
(EXTENDED AFTER PARACHUTE DEPLOYMENT. VHF/AM OR
SURVIVAL TRANSCEIVER – BEACON EQUIPMENT MAY BE CONNECTED)

Figure 3-4. Location of Command Service Module Onboard Antennas

SECTION IV
DATA ACQUISITION SYSTEMS

4.1 ELECTRONIC TRACKING DATA ACQUISITION SYSTEMS

4.1.1 C-BAND RADAR SUPPORT

4.1.1.1 Space Vehicle Launch Phase Trajectory Coverage

a. Tracking Point

C-band antenna on the IU (see Figure 3-3). The radars will share the beacons. Radar 0.18 will skintrack only. The radars are preassigned to track the CSM and launch vehicle in event of launch phase abort.

b. Frequency

The radars will interrogate the transponders on 5690 MHz and will receive the returned signal on 5765 MHz. Radar 0.18 will skintrack, radiating at 5810 MHz. The R&D radar 0.13 will also operate skintrack at 5810 MHz.

c. Measured Parameters

Azimuth angle, elevation angle, and slant range vs. time are the measured parameters.

d. Coverage

Figures 4-25 and 7-1 indicate the expected flight time coverage for metric and range safety data, respectively. The following table is a summary of radar coverage. Radar 3.13 real-time data will not be available off the ETR.

TABLE 4.1 LAUNCH PHASE TRAJECTORY RADAR COVERAGE

Radar Station No.		Radar Type	Data Rate Pts/Sec	Interval of Track	Remarks
1.16	CKAFS	FPS-16	10	Acq. to LOS	Estimated position accuracies for each radar are given. See Figures 4-8 through 4-24.
19.18	KSC	TPQ-18	20	Acq. to LOS	
*0.18	PAFB	FPQ-6	20	Acq. to LOS	
3.13	GBI	C-Band			
7.18	GTK	TPQ-18	20	Acq. to LOS	
67.18	BDA	FPQ-6	20	Acq. to LOS	
67.16	BDA	FPS-16	10	Acq. to LOS	
91.18	ANT	FPQ-6	20	Acq. to LOS	*Radar 0.18 will skin-track

e. Real-Time/Near-Real-Time Support.

Data from all the radars listed in paragraph d. above will be transmitted to the AFETR RTCS in real time.

4.1.1.2 Meteorological Balloon Support

a. Tracking Point.

The radar will track Jimspheres released at CKAFS.

b. Frequency.

5660 - 5825 MHz.

c. Measured Parameters.

Azimuth angle, elevation angle, and slant range vs. time are the measured parameters.

d. Coverage.

Radar 1.16 will be used to track each balloon for approximately one hour. Radars 0.18 or 19.18 may be used if radar 1.16 is not available.

e. Real-Time/Near-Real-Time Support

The data will be transmitted to the CIF during the balloon ascent for each balloon released in support of the mission.

4.1.2 UNIFIED S-BAND SUPPORT

a. Tracking Point

The following are the tracking points:

(1) The USB transponder antennas on the CSM and the LM.

(2) The CCS transponder antennas on the IU (see Figure 3-3).

b. Frequency

PRN code will be transmitted from the ground station to the CSM transponder on a frequency of 2106.4 MHz and will be returned to the ground station on a frequency of 2287.5 MHz. The LM receive and transmit frequencies are 2101.8 and 2282.5 MHz, respectively. The CCS utilizes the same frequencies as the LM USB system.

c. Measured Parameters

Azimuth angle, elevation angle, and slant range vs. time are the measured parameters.

d. Coverage

The KSC and Bermuda USB stations will support AS-510 during the launch phase of the mission. The USB stations provide tracking, telemetry, communication, and up-data support. The USNS Vanguard will provide USB coverage for insertion and will be located at 25°N, 49°W.

e. Real-Time/Near-Real-Time Support

USB data will be transmitted to MCC-H in real time by GSFC.

4.1.3 RENDEZVOUS RADAR SUPPORT. The X-band rendezvous radar is located in the LM and the transponder on the CSM. The system will be inactive during the launch phase and is activated in lunar rendezvous operations.

4.1.4 LANDING RADAR SUPPORT. The lunar landing radar located in the LM and used to provide altitude and velocity data, will be carried. The radar employs 10510 MHz and 9580 MHz for velocity and altitude measurements, respectively. The radar is inactive during the launch phase.

4.2 OPTICAL DATA ACQUISITION SYSTEMS

4.2.1 METRIC OPTICAL DATA ACQUISITION SUPPORT

4.2.1.1 Vertical Motion Cameras

a. Tracking Point

The camera is locked in position to record the passage of the vertical motion target (see Figure 3-1) through the field of view. Data are referenced to this target.

b. Camera Size

35 mm

c. Reduced Data

Vertical motion vs. time.

d. Coverage

One camera at the 160-foot level of the umbilical tower, positioned to include a fixed reference target in the field of view will provide coverage during the first 5 to 7 meters of vehicle ascent. The frame rate is 96 frames per second.

e. Real-Time/Near-Real-Time Support

Not applicable

4.2.1.2 First Motion Cameras

a. Tracking Point

The cameras are locked in position to view the first motion targets. (See Figure 3-1.)

b. Camera Size

16 mm

c. Reduced Data

Time of vehicle first motion

d. Coverage

Two cameras, located at the zero level of the umbilical tower, will view first motion targets. The cameras operate at 400 frames per second.

e. Real-Time/Near-Real-Time Support

Not applicable.

4.2.2 PHOTOGRAPHIC SUPPORT

4.2.2.1 <u>Documentary Coverage</u>. A documentary history of the mission will be recorded on film. Detailed information concerning this coverage may be obtained from IS-DOC-2, Photographic Branch, telephone 867-6002.

4.2.2.2 <u>Engineering Sequential Coverage</u>. The engineering sequential coverage will be described in the KSC Photographic Acquisition-Disposition Document (PADD). Devices providing long-range high-resolution optical coverage are listed below:

a. IGOR Tracking Telescopes

Two IGOR systems will support the AS-510 launch. Locations will be at Ponce de Leon Inlet (MITTS) and at PAFB. The fixed IGOR system at PAFB will provide TV video coverage to the RSO, LCC, and LC-39 press site.

b. ROTI Tracking Telescopes

One ROTI located at Melbourne will support the AS-510 launch.

4.2.3 TELEVISION SUPPORT

4.2.3.1 <u>ETR Television Support</u>

4.2.3.1.1 Range Safety Television Support. One Flightline and two Program TV cameras will provide the RSO visual coverages of the vehicle launch. The Flightline camera is located at FCVP-2 (FIM-8) (see Figure 4-3). Program I camera is located just north of UC-2 (FIM-7) on KSC (Figure 4-3).

4.2.3.1.2 Launch Vehicle Coverage. The PAFB IGOR tracking telescope will be equipped with a TV camera. Display will include the RSO, Abort Advisory Console at the LCC, and LC-39 press site.

4.2.3.2 GSFC Television Support. The KSC USB Ground Station will monitor and record the prelaunch TV transmissions originating in the CM and LM. The TV systems are inactive during the launch phase.

4.2.3.3 KSC Television Support

4.2.3.3.1 Abort System Television Coverage. Six cameras will view the vehicle to provide abort advisory information: Two located on the LUT, two in the pad area, and one remote long-range camera (ETR supplied) adjacent to the Range Safety Flightline TV camera. The IGOR at PAFB provides long-range coverage.

4.2.3.3.2 Operational Television (OTV) Support. Sixty TV cameras as listed will support the launch:

12 - Mobile Service Structure (MSS)
27 - Launch Umbilical Tower
18 - Pad Area
2 - Firing Room
1 - VIB or VAB

4.3 TELEMETRY SYSTEMS

4.3.1 ETR TELEMETRY SUPPORT. The following ETR facilities are expected to provide coverage of the VHF telemetry links listed in Table 3.2.

a. Airborne TLM coverage - Four ARIA aircraft will support the mission after the launch phase.

b. Uprange TLM Stations - Station 19 (TEL IV) - This station will route certain data in real time to the ETR for range safety purposes.

c. Downrange Telemetry Stations - Station 91 (Antigua) - This station will route certain data in real time for range safety purposes.

d. Shipborne Coverage - No ETR ship coverage is planned.

4.3.2 GSFC TELEMETRY SUPPORT. The following GSFC MSFN facilities will provide launch-phase telemetry coverage of certain selected VHF links on the launch vehicle and the S-band links on the IU and CSM:

S-Band	VHF
KSC	KSC
Bermuda	Bermuda
Vanguard	Vanguard
(Insertion Ship)	

The KSC USB site will transmit 51.2 kbs PCM to CIF for processing and relay to MCC-H via the ALDS equipment.

4.3.3 KSC TELEMETRY SUPPORT. The following KSC facilities will monitor the VHF and S-band telemetry links in support of space vehicle checkout operations:

a. LC-39 Telemetry GSE - Launch vehicle data (RF and hardline) are acquired by the DDAS during checkout and during the countdown until T-0. These data are displayed in the LCC and are routed to the Data-Core in the CIF.

b. CIF TLM Station - VHF and S-band RF data are received at the CIF Ground Station using either the CIF Antenna Site or the MILA USB Station. The data are routed to Data-Core for local CIF recording, display, and retransmission to MSC, MSFC, LC-39, and MSOB.

c. CIF Antenna Field Receivers - VHF and S-band TLM receivers located at the CIF Antenna Field will acquire the radiated telemetry data. These data will be routed to the CIF Data-Core.

d. MSOB ACE Station - Acceptance Checkout Equipment located in the MSOB will receive spacecraft hardline or RF data. The Quick-Look Data System (QLDS) at the MSOB also receives, processes and displays RF and hardline TLM data.

e. MILA USB Station - S-band and VHF equipment will acquire, process and retransmit SC and launch vehicle data.

4.4 FREQUENCY CONTROL AND ANALYSIS

4.4.1 C-Band Beacon Checkout. IU C-band Beacon 1 and 2 are checked out prior to launch by EMC vans and in conjunction with Radar 1.16.

4.4.2 Spurious Emission Search. The KSC EMC Van will provide RFI search and record coverage from 100 MHz to 10 GHz.

4.4.3 Command and Astronaut Voice Link Record. The KSC Van will record UHF command and Astronaut Voice link signal strength while vehicle RF is radiating open loop. In addition, the UHF command link will be recorded from the roof of the VAB.

4.4.4 Power Line Transient Record. Equipment will monitor CIF power line transients.

4.5 SURFACE INSTRUMENTATION SUMMARY

Locations of the data acquisition systems planned to support this mission are shown in Figures 4-1 through 4-4. Elevation angles from the major land-based tracking stations for the launch phase are shown in Figures 4-5, 4-6, and 4-7. The expected flight time coverage for metric trajectory coverage is given in Figure 4-25. The estimated accuracies of the C-band radars are given in Figures 4-8 through 4-24.

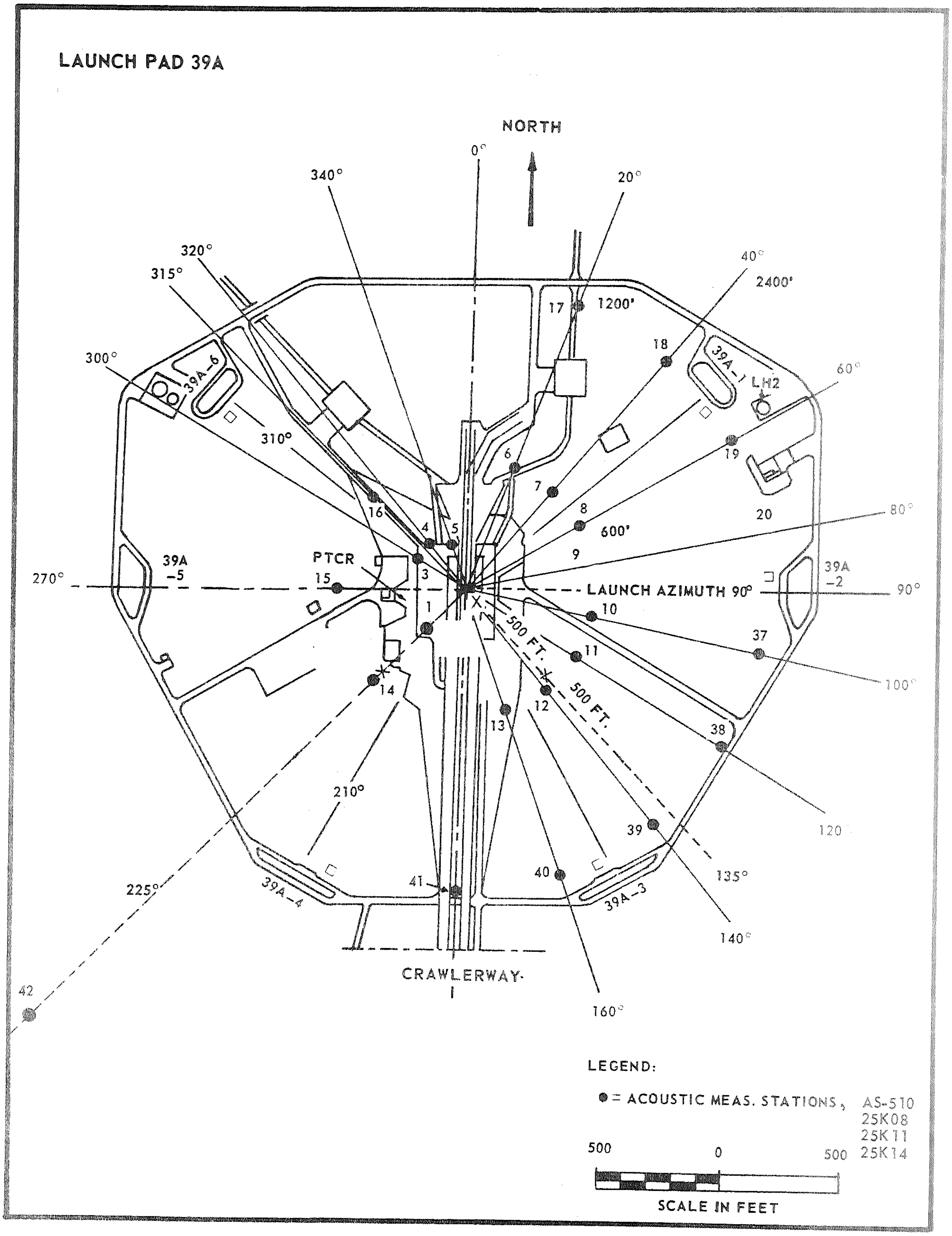


Figure 4-1. Close-In Instrumentation

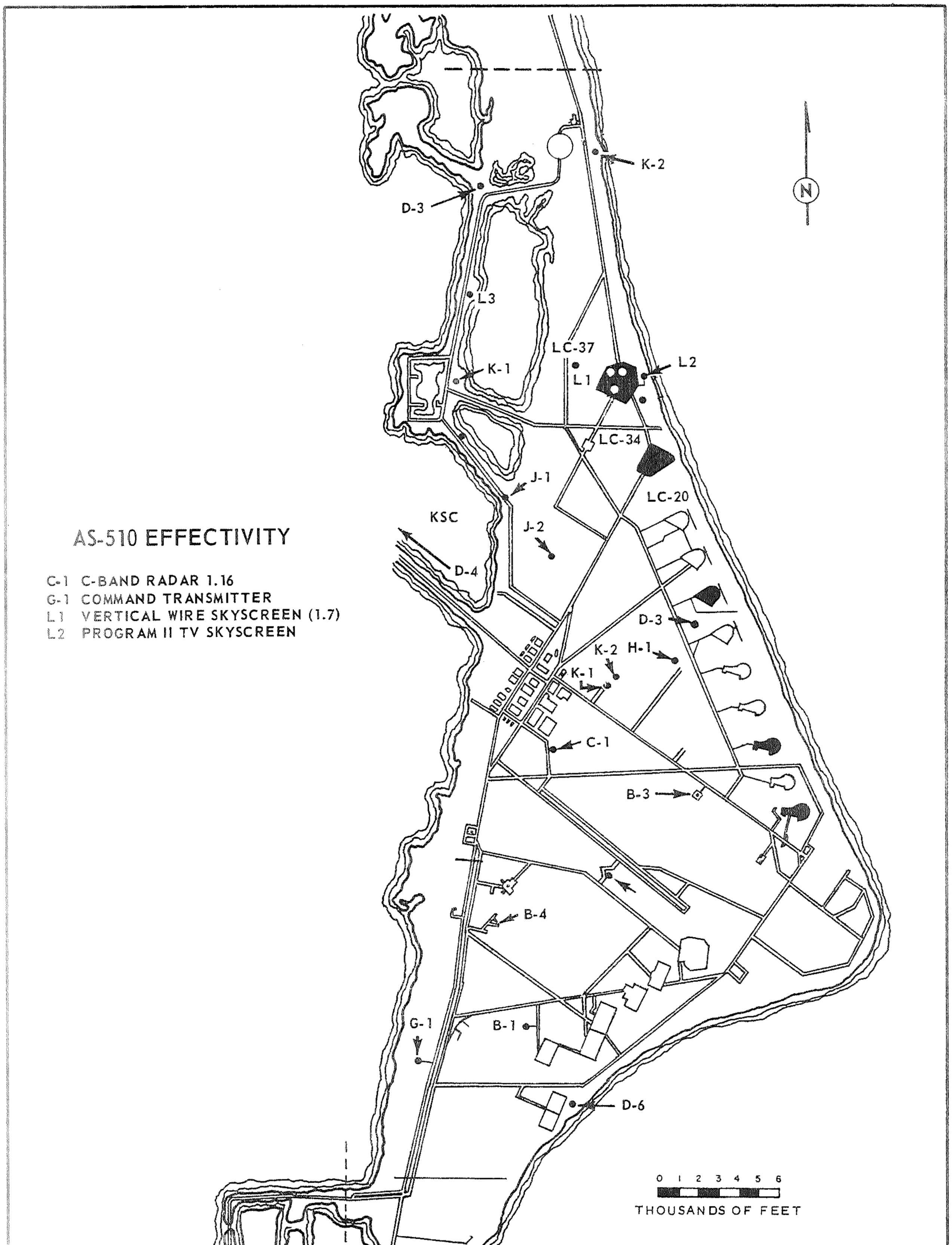


FIGURE 4-2. CAPE INSTRUMENTATION

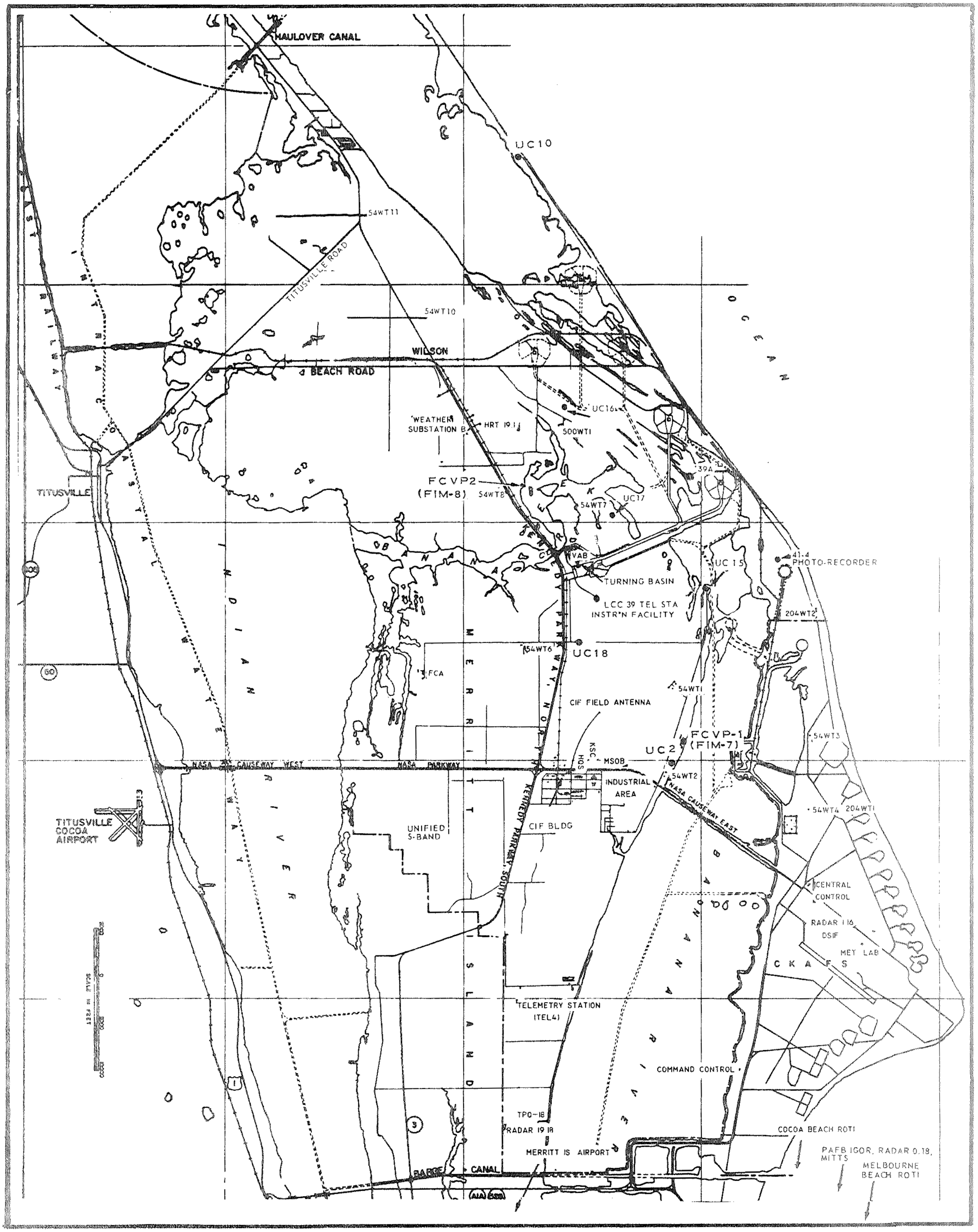
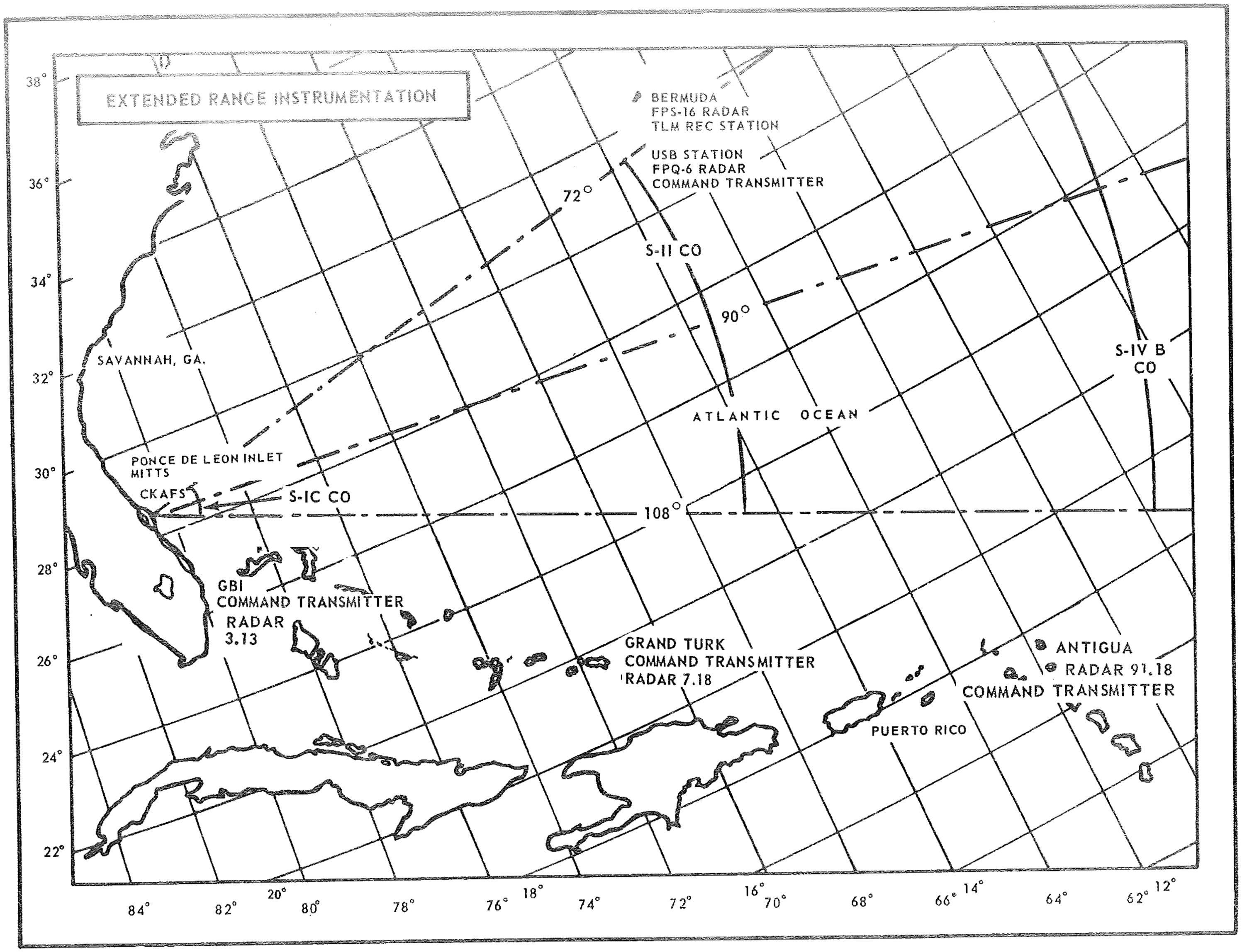


Figure 4-3. Uprange Instrumentation



AS-510 Fl. Az. Limits 80.088° - 100°

Figure 4-4. Extended Range Instrumentation

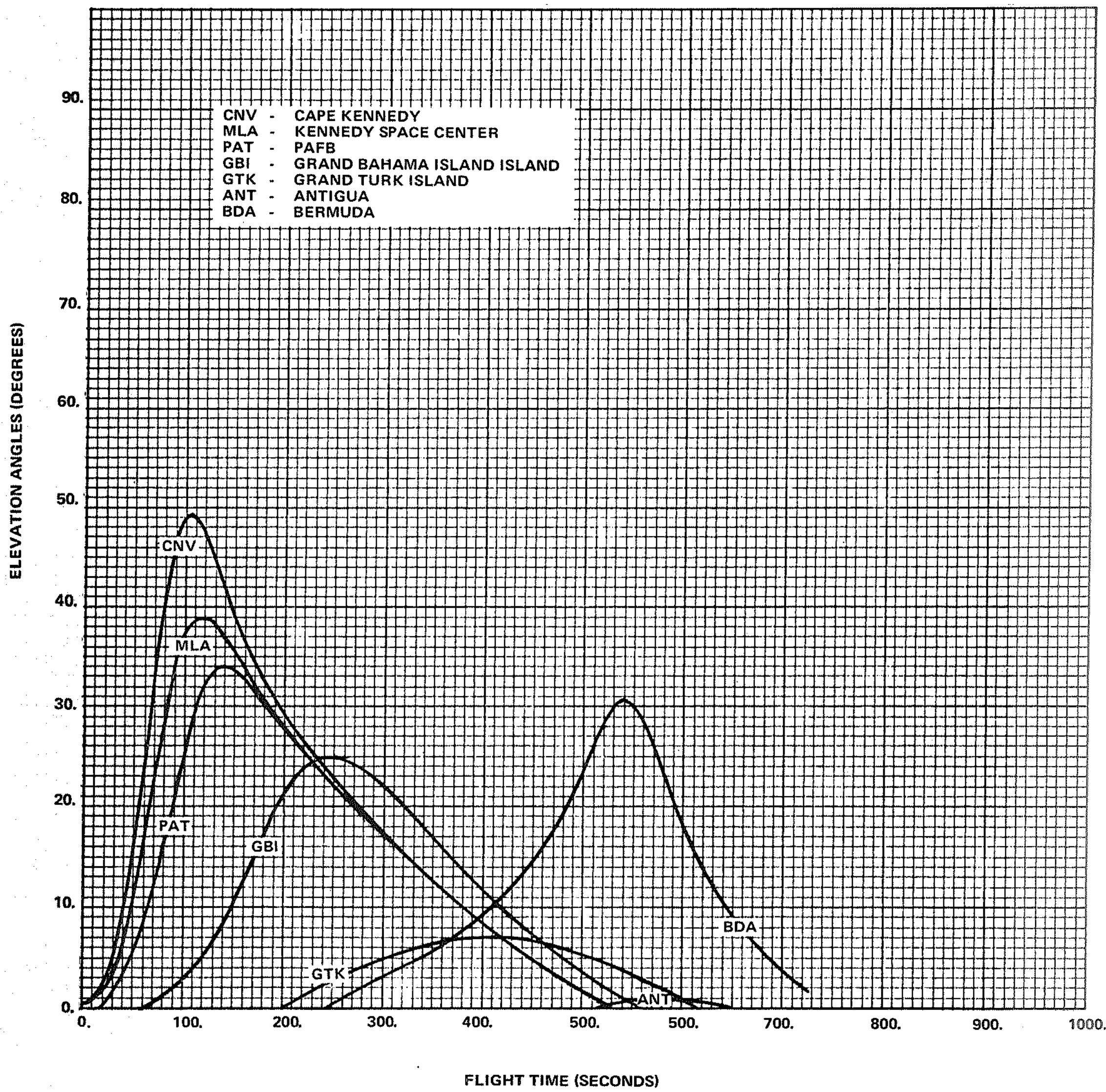


FIGURE 4-5. ELEVATION ANGLES FROM MAJOR LAND-BASED TRACKING STATIONS, AS-510 (F.A. 80°)

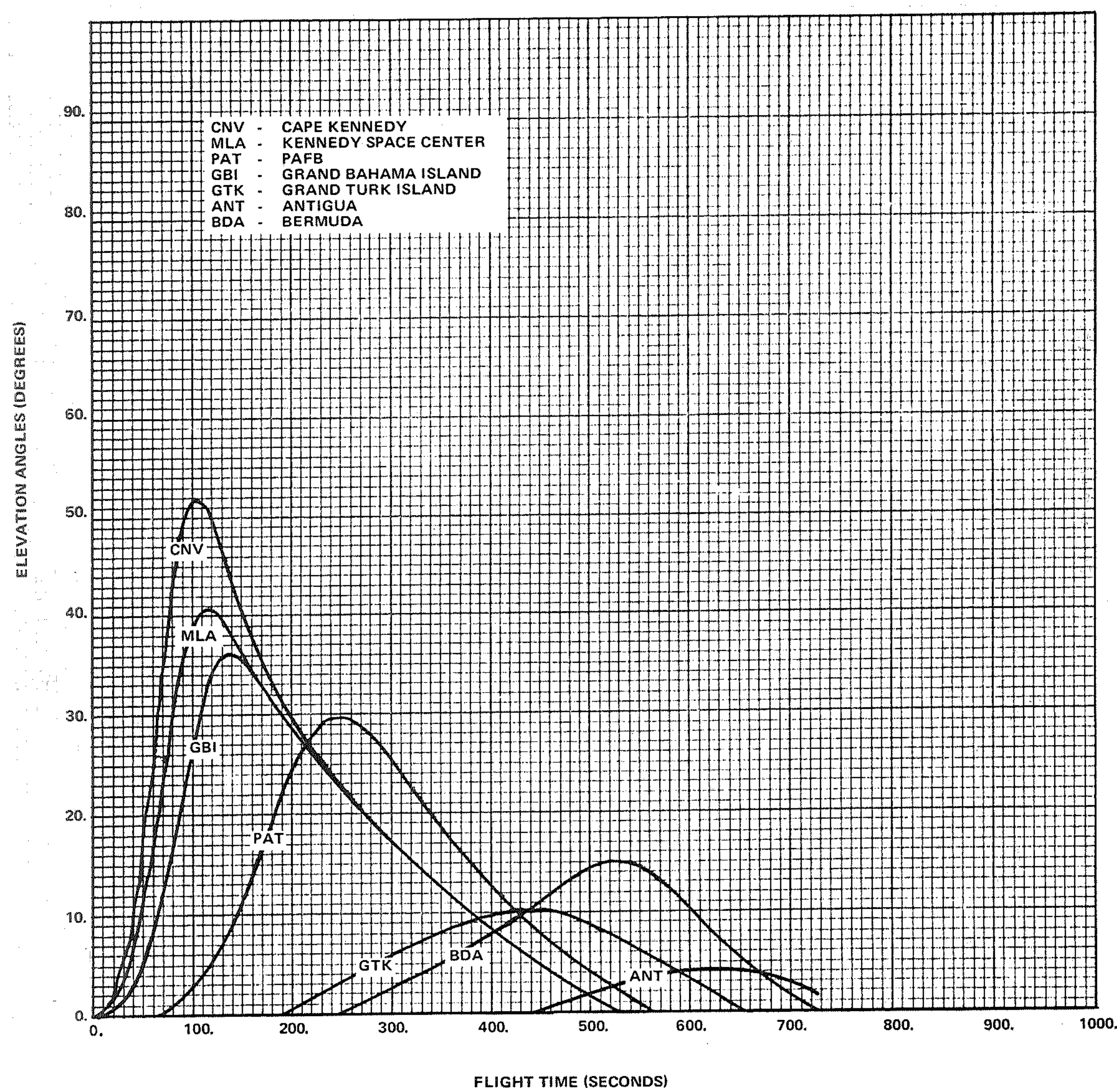


FIGURE 4-6. ELEVATION ANGLES FROM MAJOR LAND-BASED TRACKING STATIONS, AS-510 (F.A. 90°)

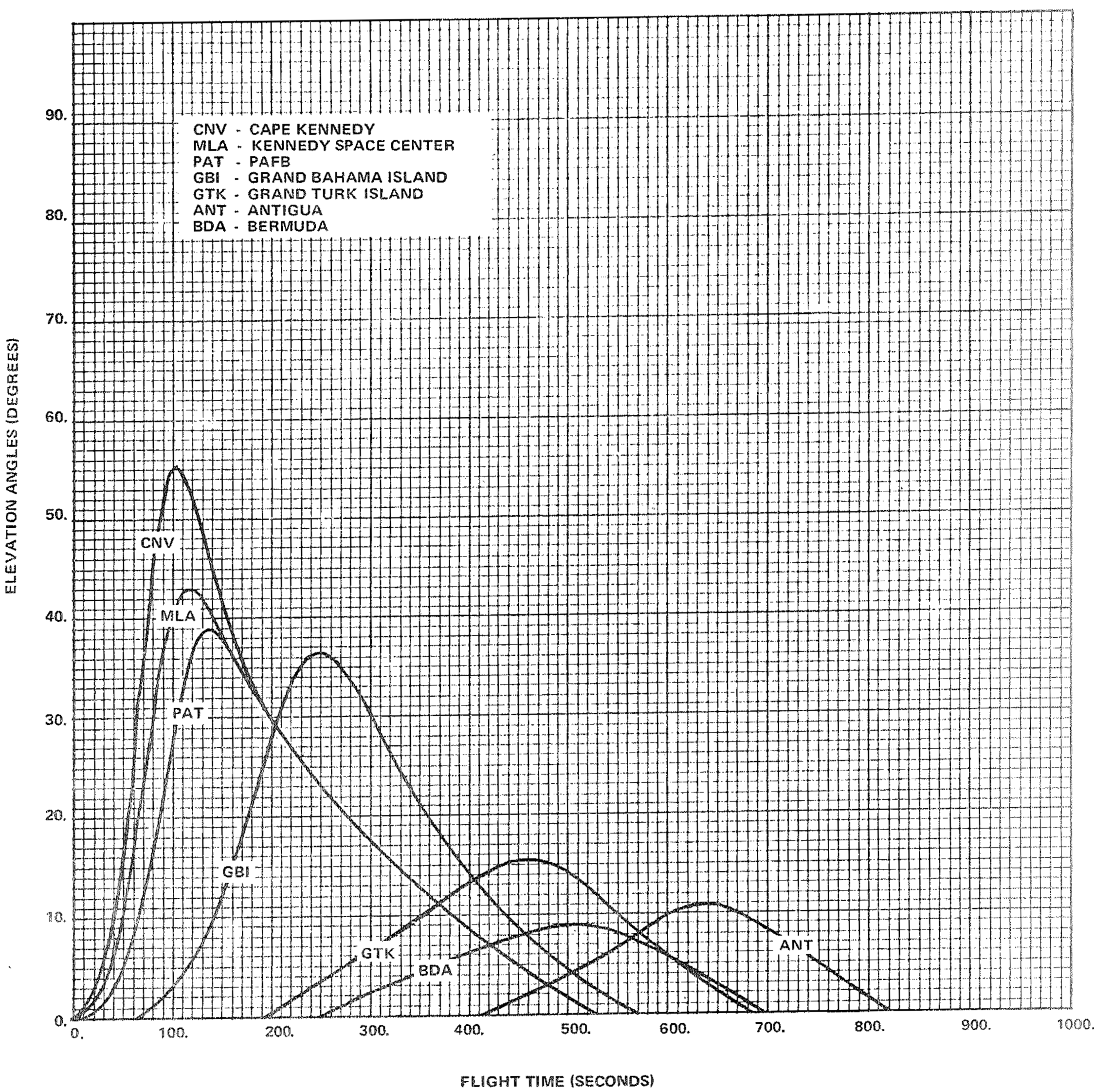


FIGURE 4-7. ELEVATION ANGLES FROM MAJOR LAND-BASED TRACKING STATIONS, AS-510 (F.A. 100°)

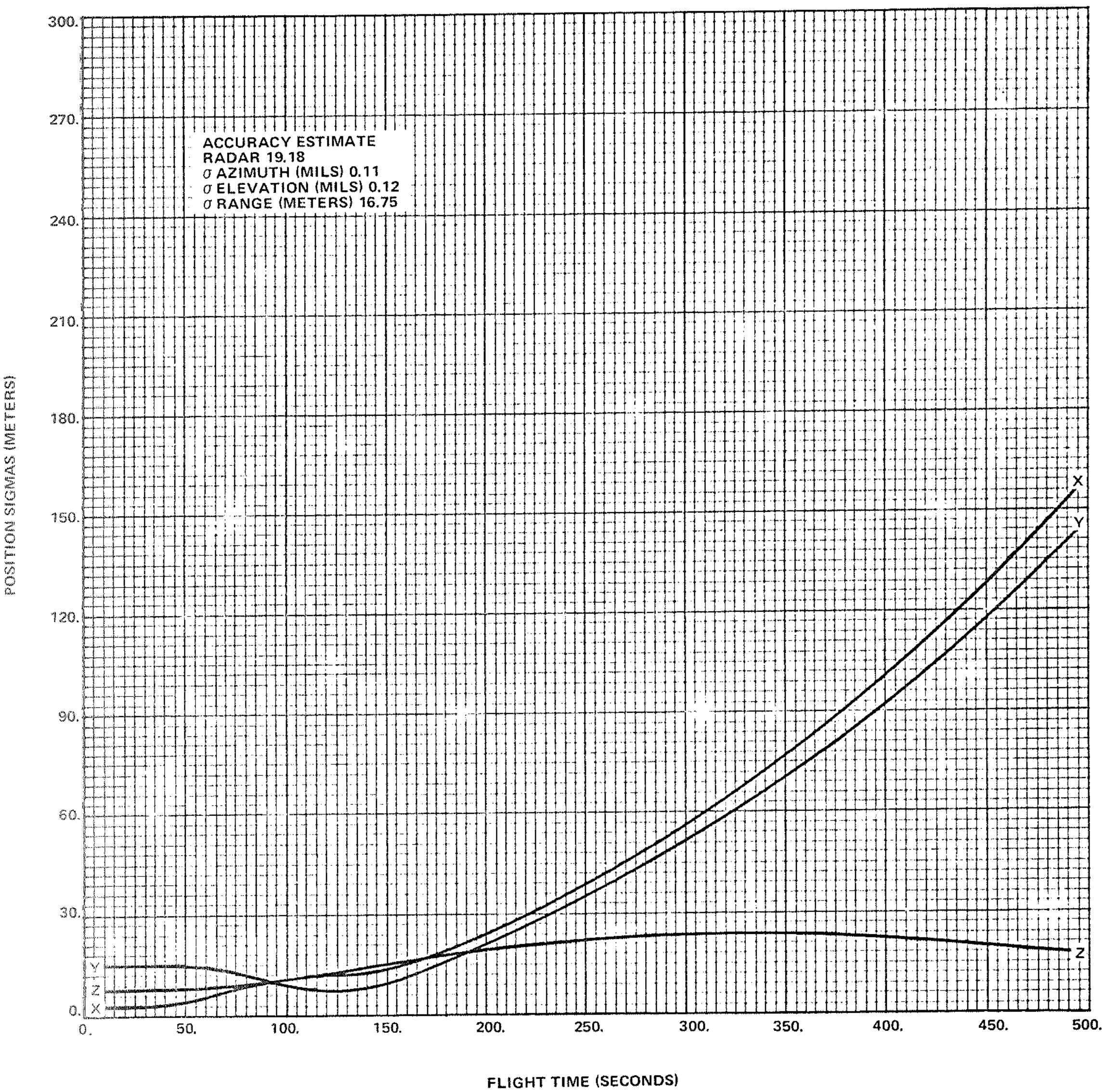


FIGURE 4-8. ESTIMATES OF KSC C-BAND RADAR 19.18 POSITION ACCURACIES, AS-510 (F.A. 80°)

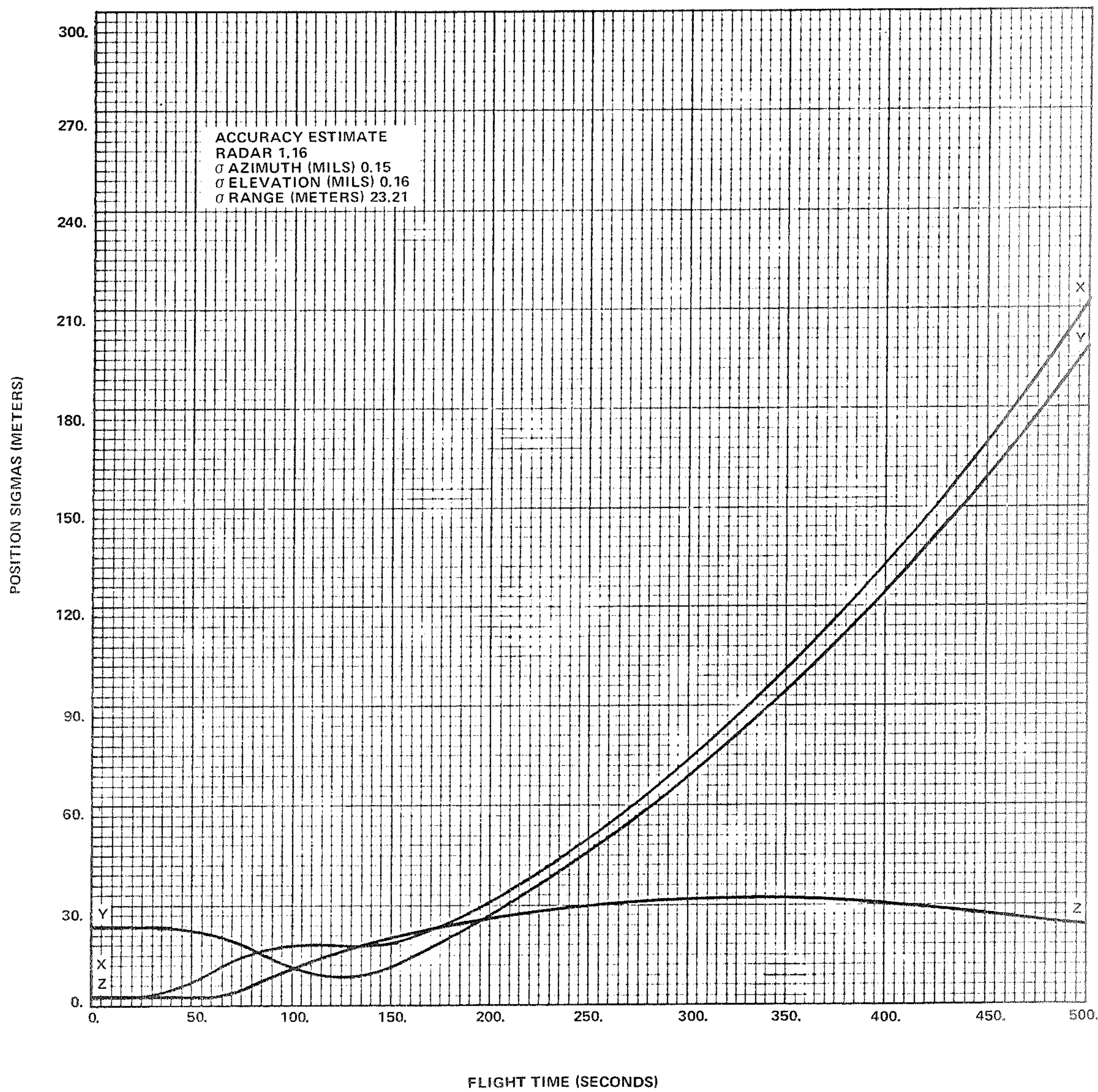


FIGURE 4-9. ESTIMATES OF CAPE KENNEDY C-BAND RADAR 1.16 POSITION ACCURACIES, AS-510 (F.A. 80°)

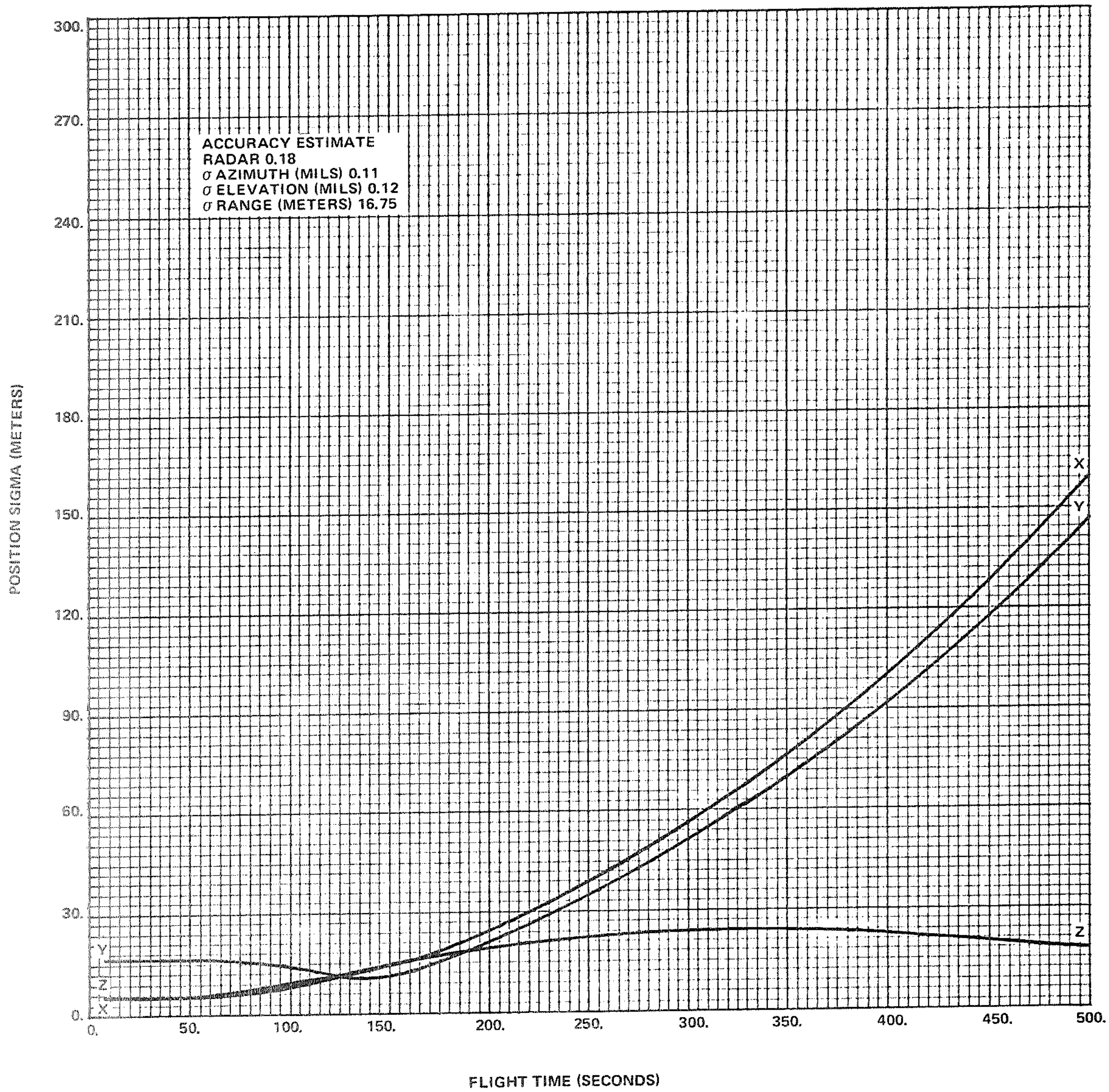


FIGURE 4-10. ESTIMATES OF PAFB C-BAND RADAR 0.18 POSITION ACCURACIES, AS-510 (F.A. 80°)

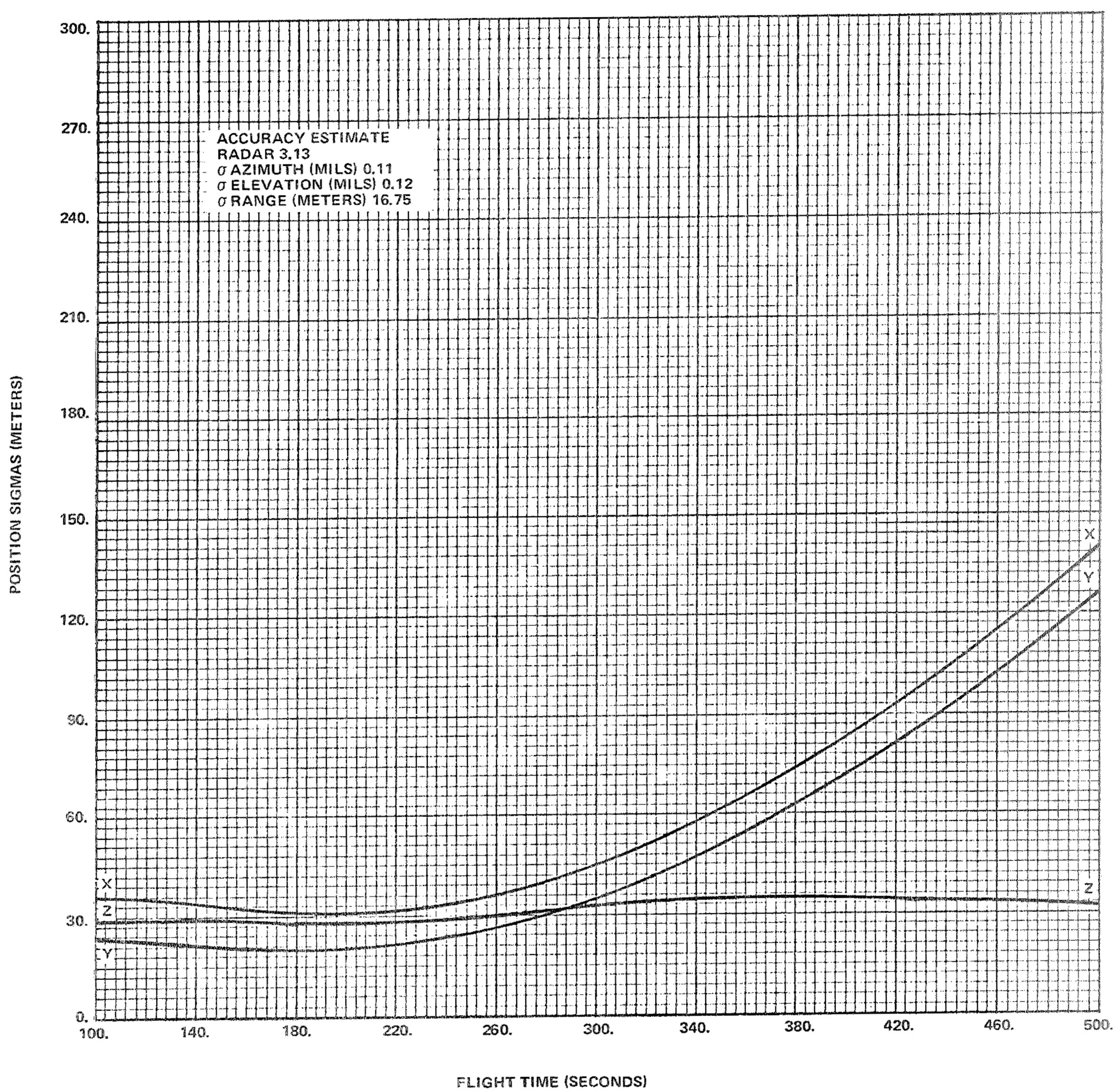


FIGURE 4-11. ESTIMATES OF GBI C-BAND RADAR 3.13 POSITION ACCURACIES, AS-510 (F.A. 80°)

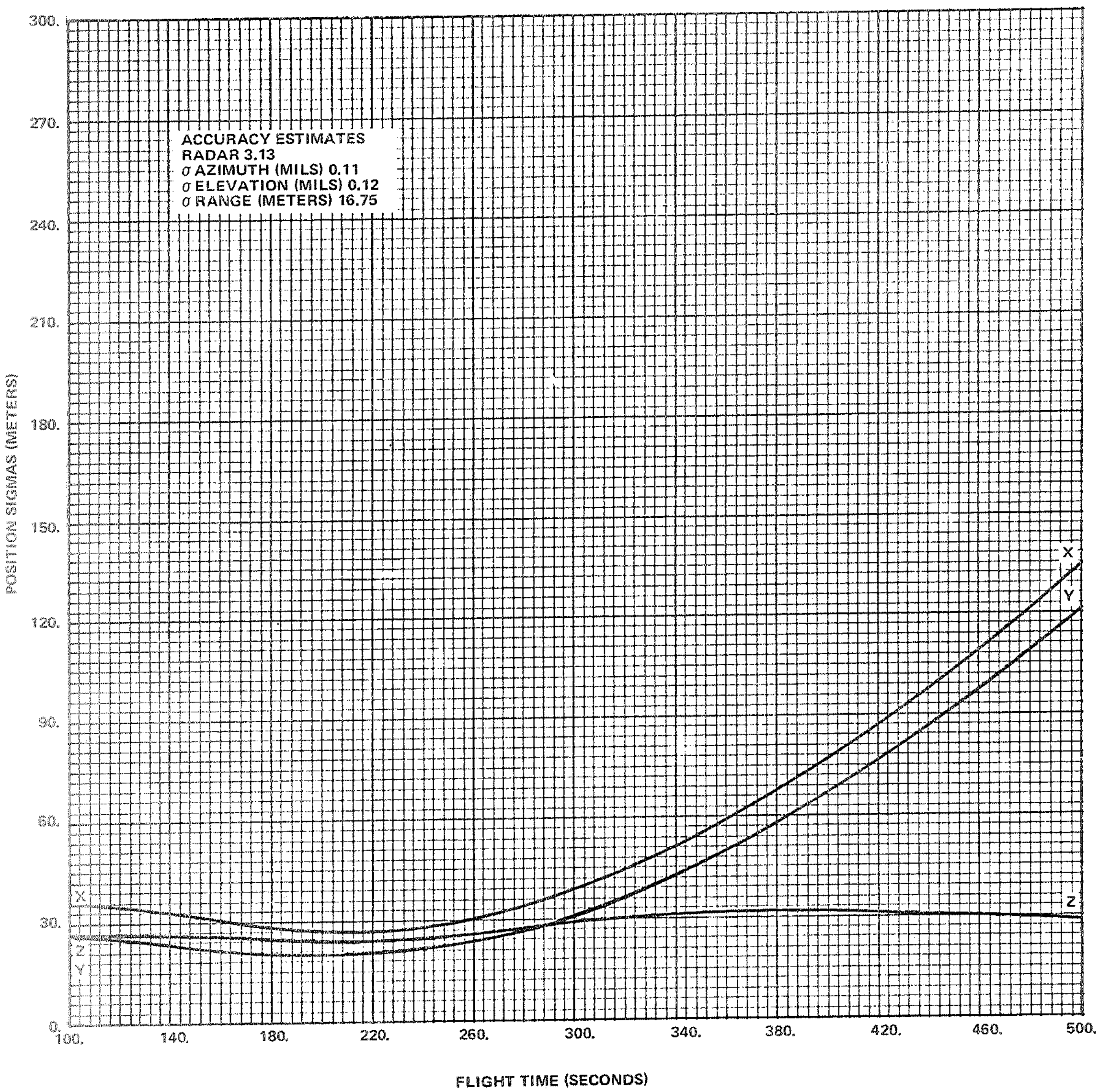


FIGURE 4-12. ESTIMATES OF GBI C-BAND RADAR 3.13 POSITION ACCURACIES, AS-510 (F.A. 90°)

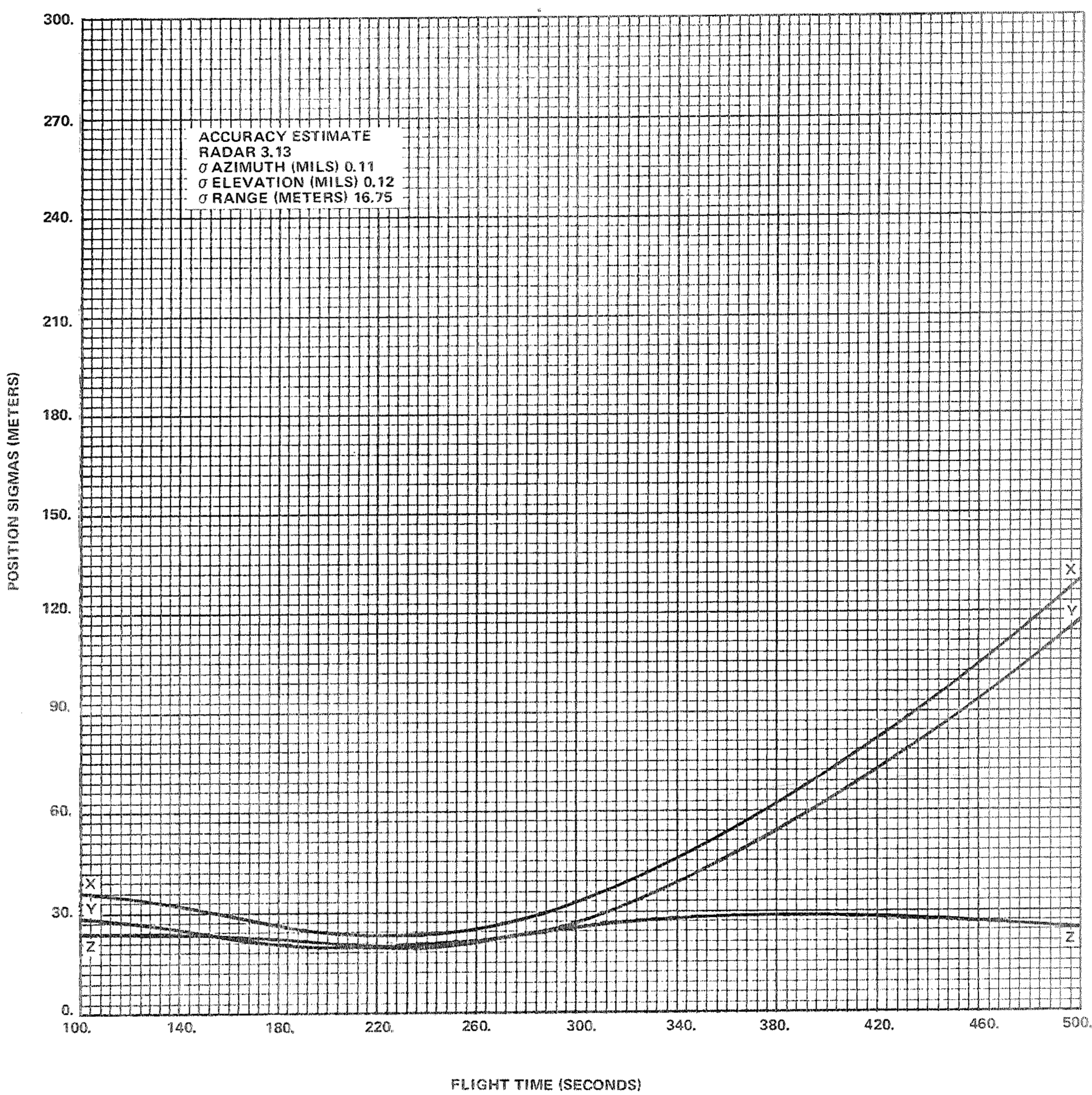


FIGURE 4-13. ESTIMATES OF GBI C-BAND RADAR 3.13 POSITION ACCURACIES, AS-510 (F.A. 100°)

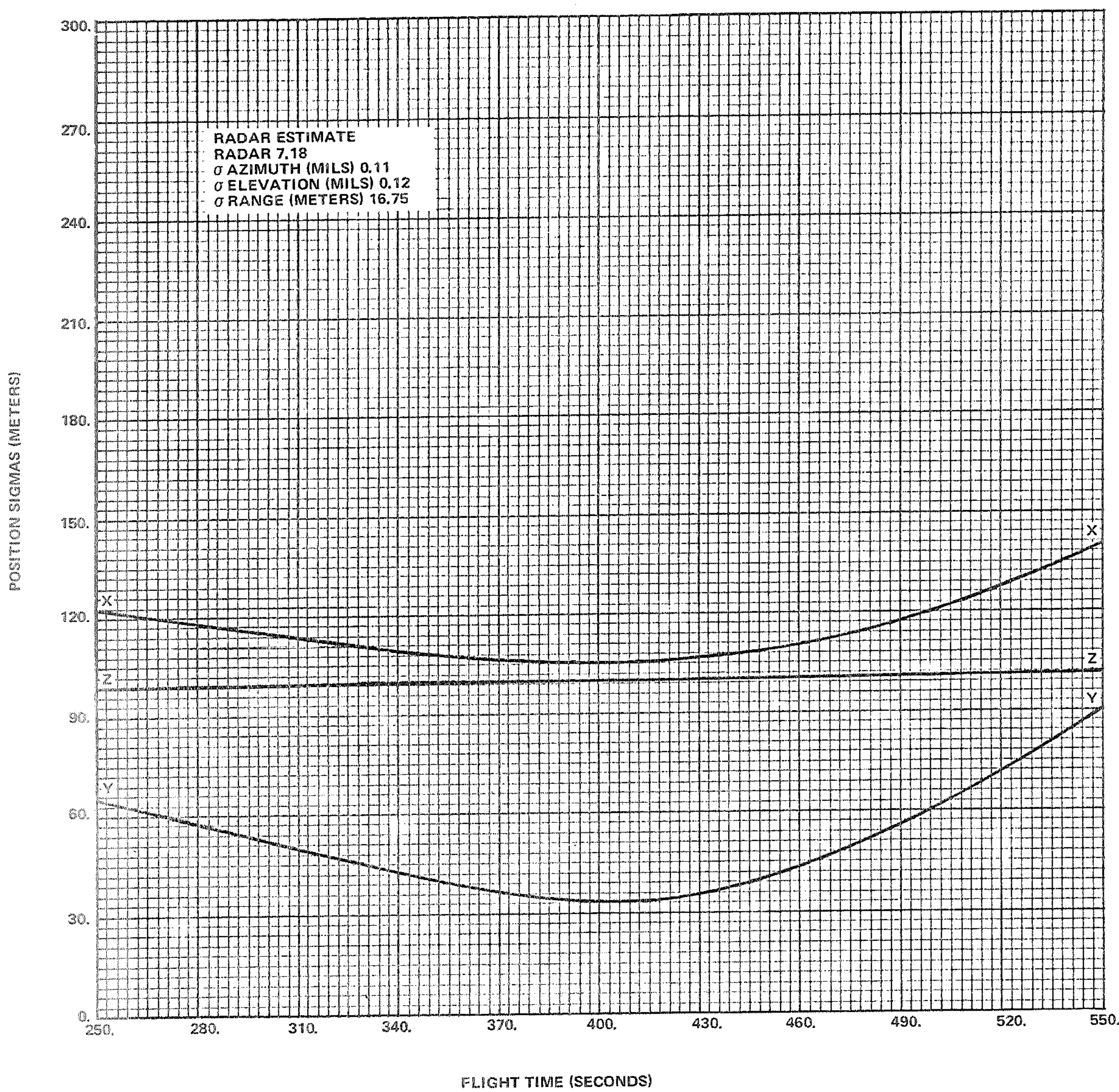


FIGURE 4-14. ESTIMATES OF GRAND TURK ISLAND C-BAND RADAR 7.18 POSITION ACCURACIES, AS-510 (F.A. 80°)

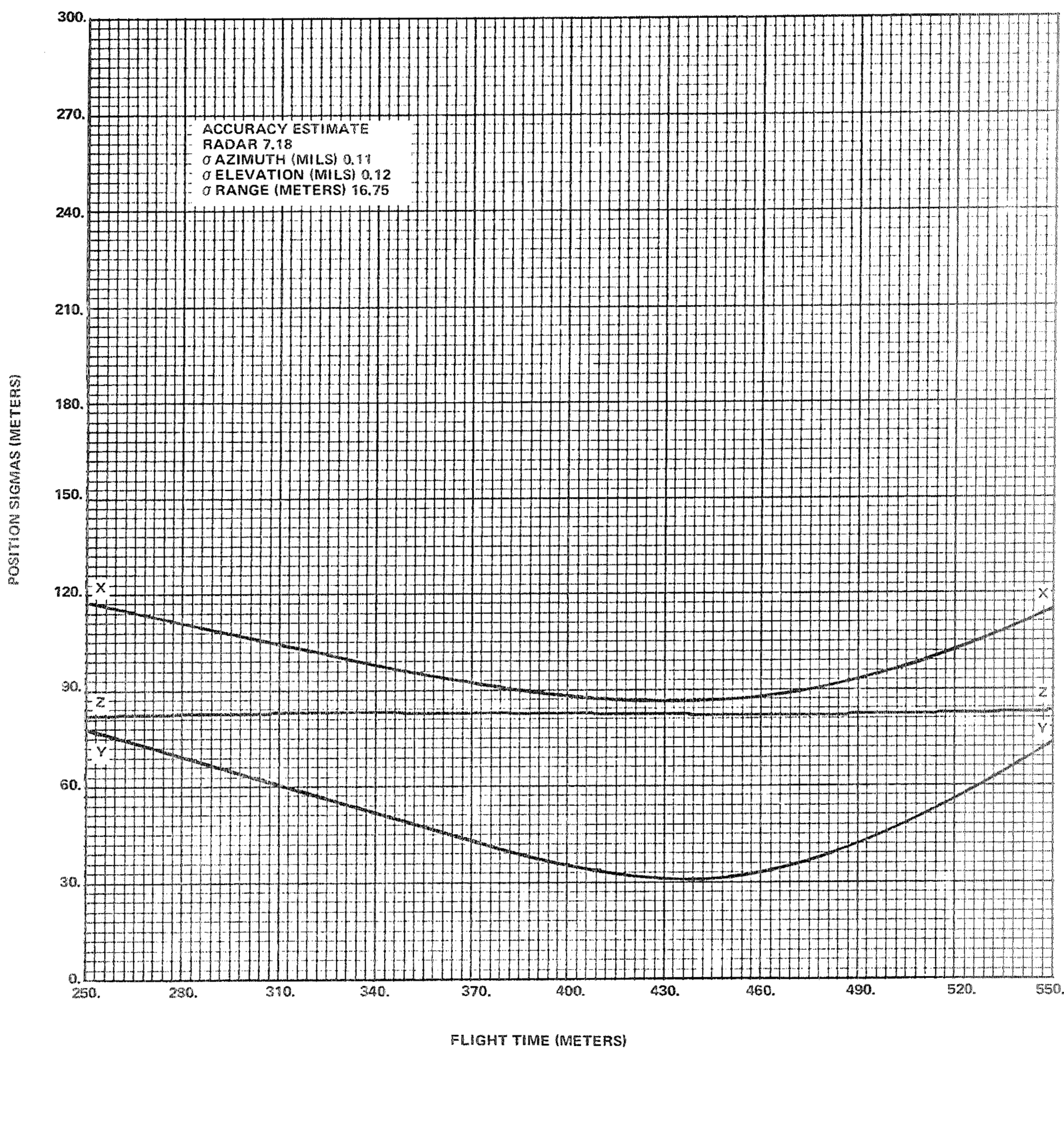


FIGURE 4-15. ESTIMATES OF GRAND TURK ISLAND C-BAND RADAR 7.18 POSITION ACCURACIES, AS-510 (F.A. 90°)

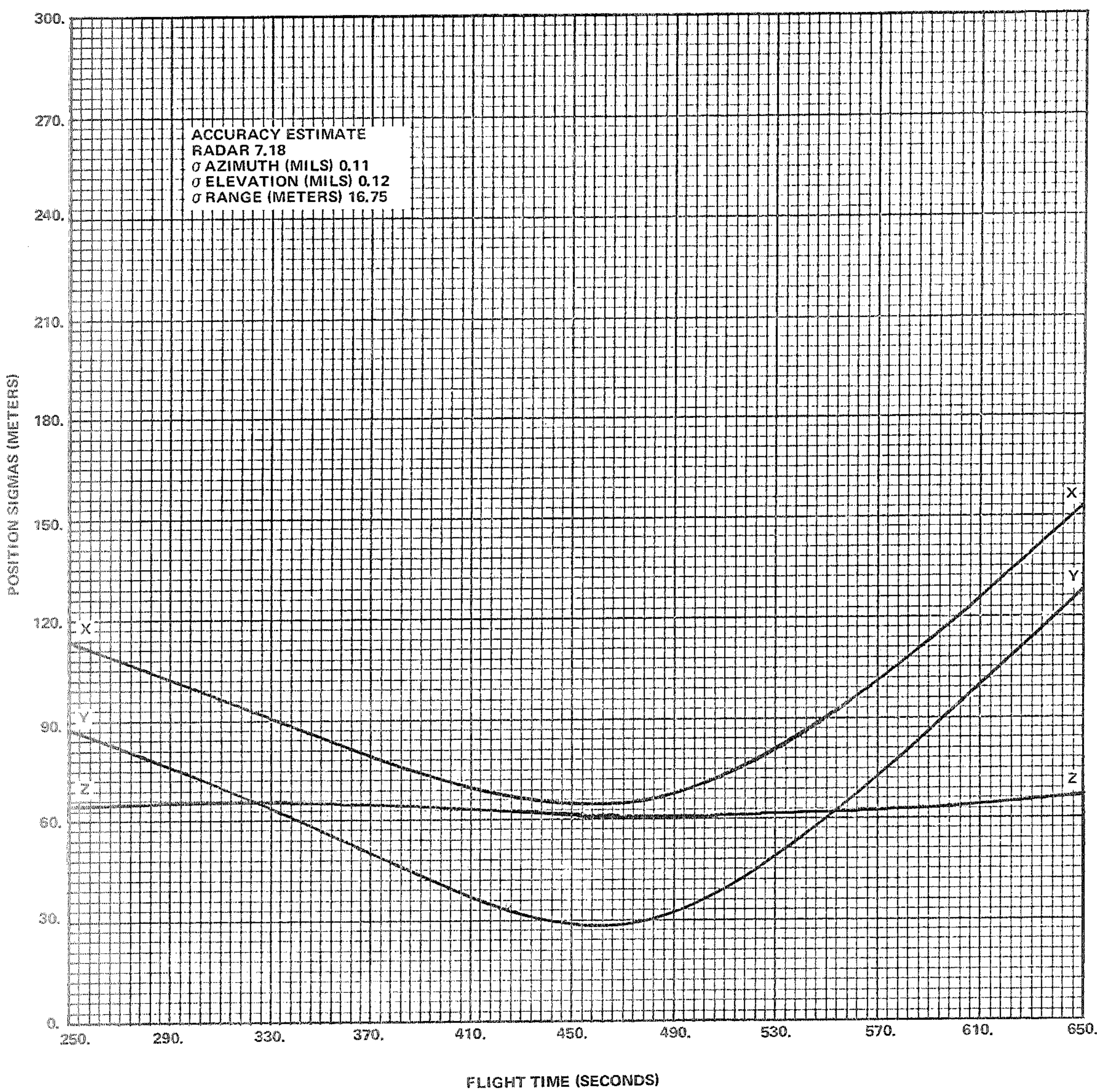


FIGURE 4-16. ESTIMATES OF GRAND TURK ISLAND C-BAND RADAR 7.18 POSITION ACCURACIES, AS-510 (F.A. 100°)

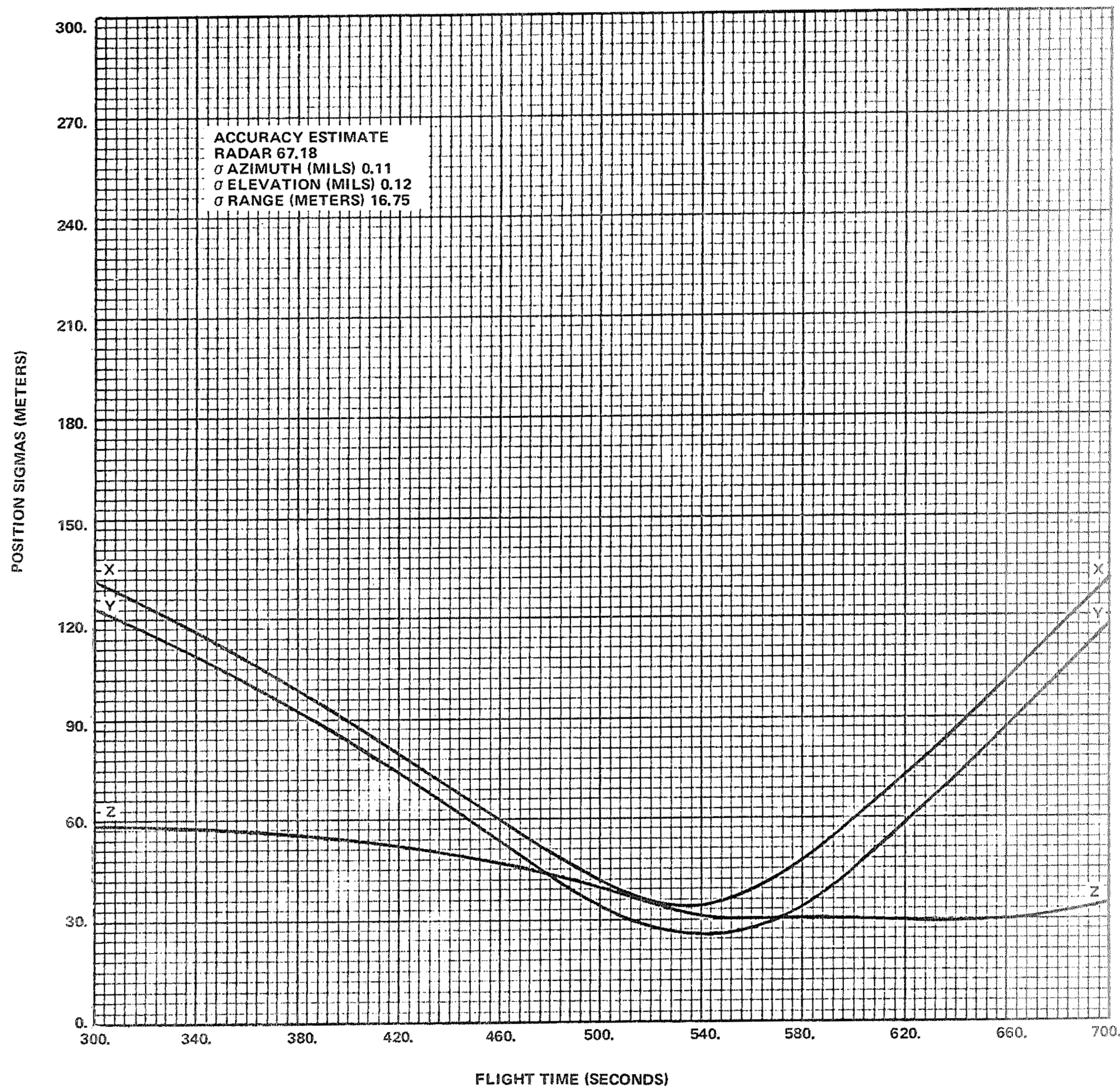


FIGURE 4-17. ESTIMATES OF BERMUDA C-BAND RADAR 67.18 POSITION ACCURACIES, AS-510 (F.A. 80°)

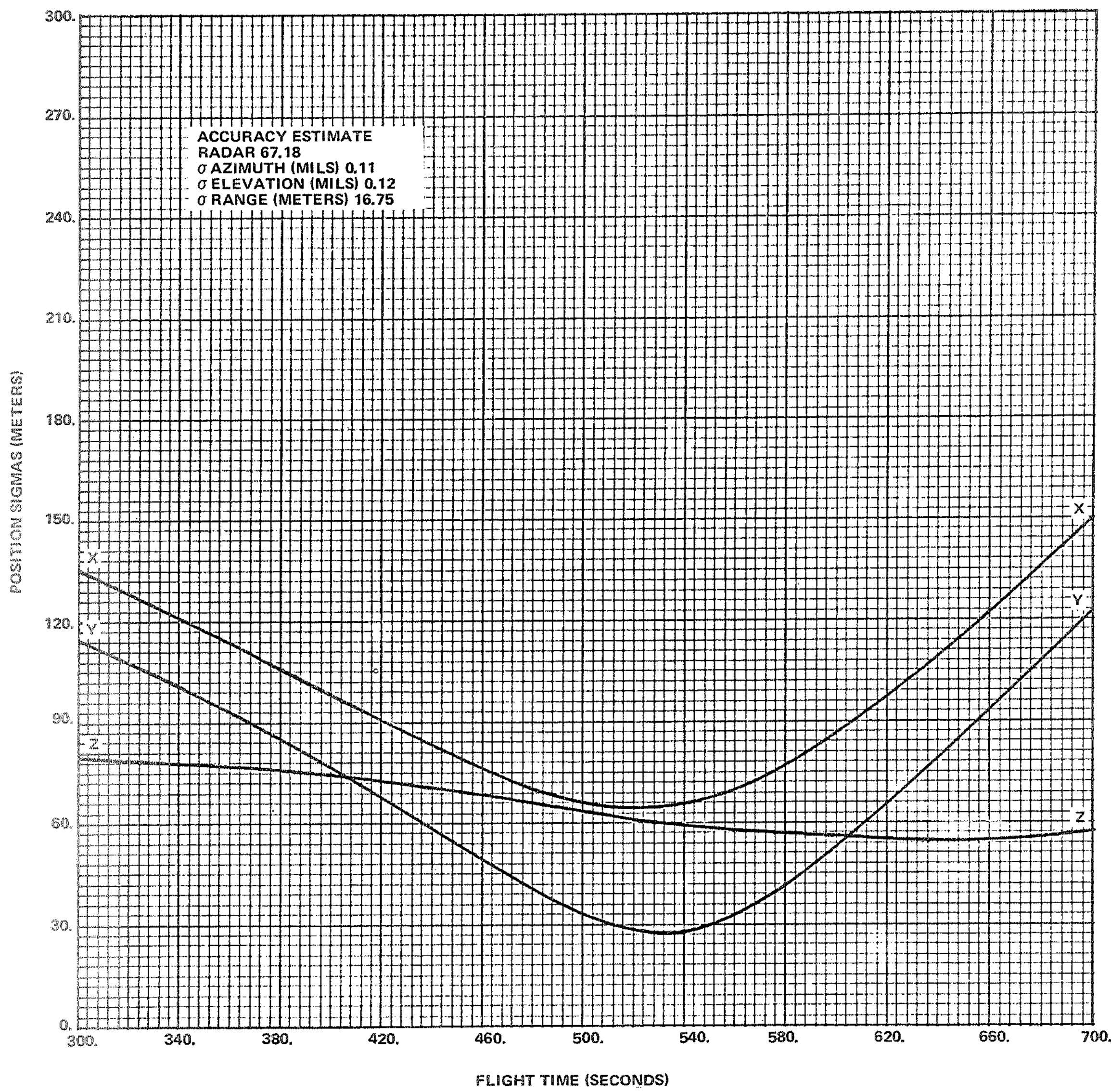


FIGURE 4-18. ESTIMATES OF BERMUDA C-BAND RADAR 67.18 POSITION ACCURACIES, AS-510 (F.A. 90°)

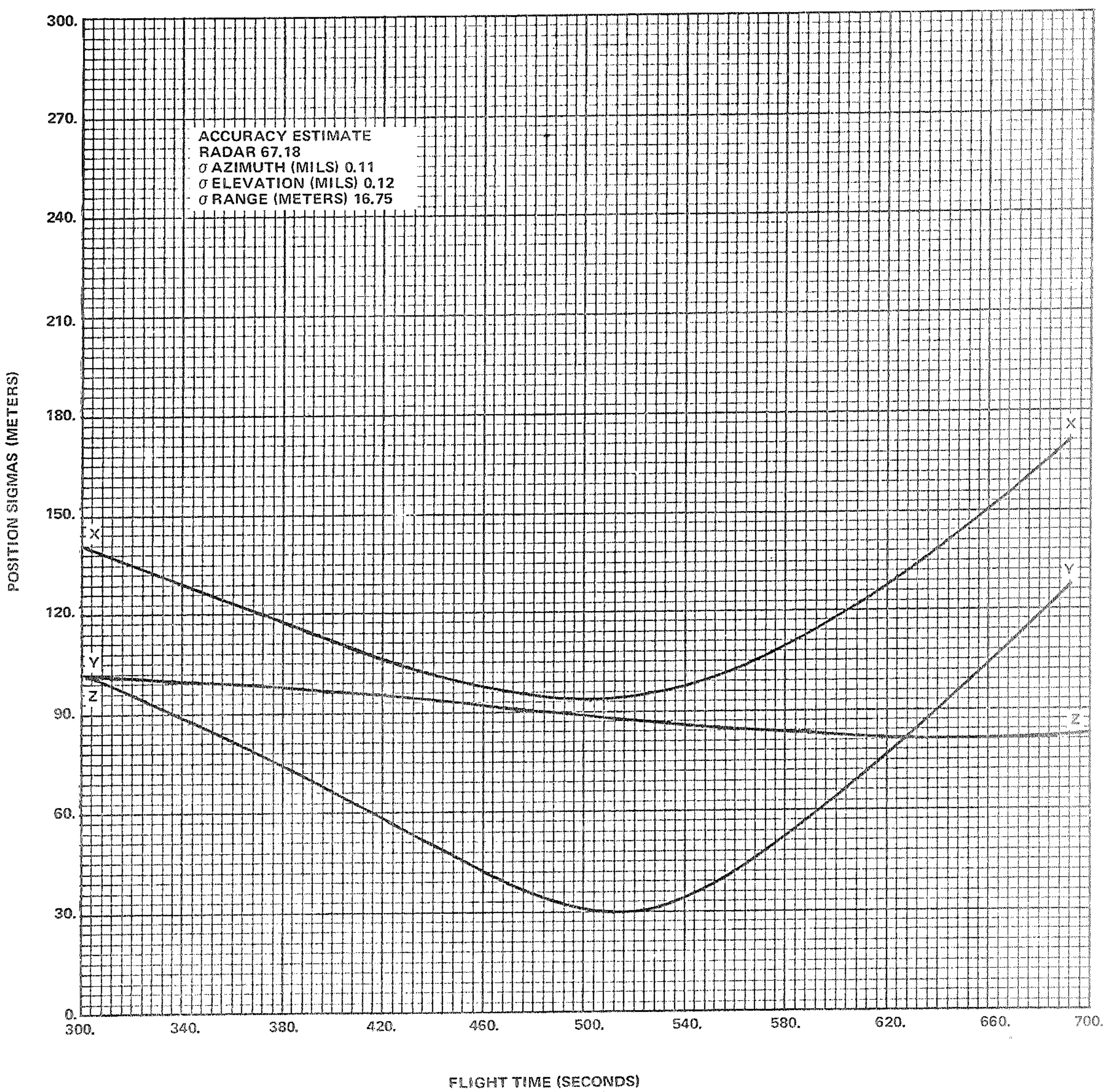


FIGURE 4-19. ESTIMATES OF BERMUDA C-BAND RADAR 67.18 POSITION ACCURACIES, AS-510 (F.A. 100°)

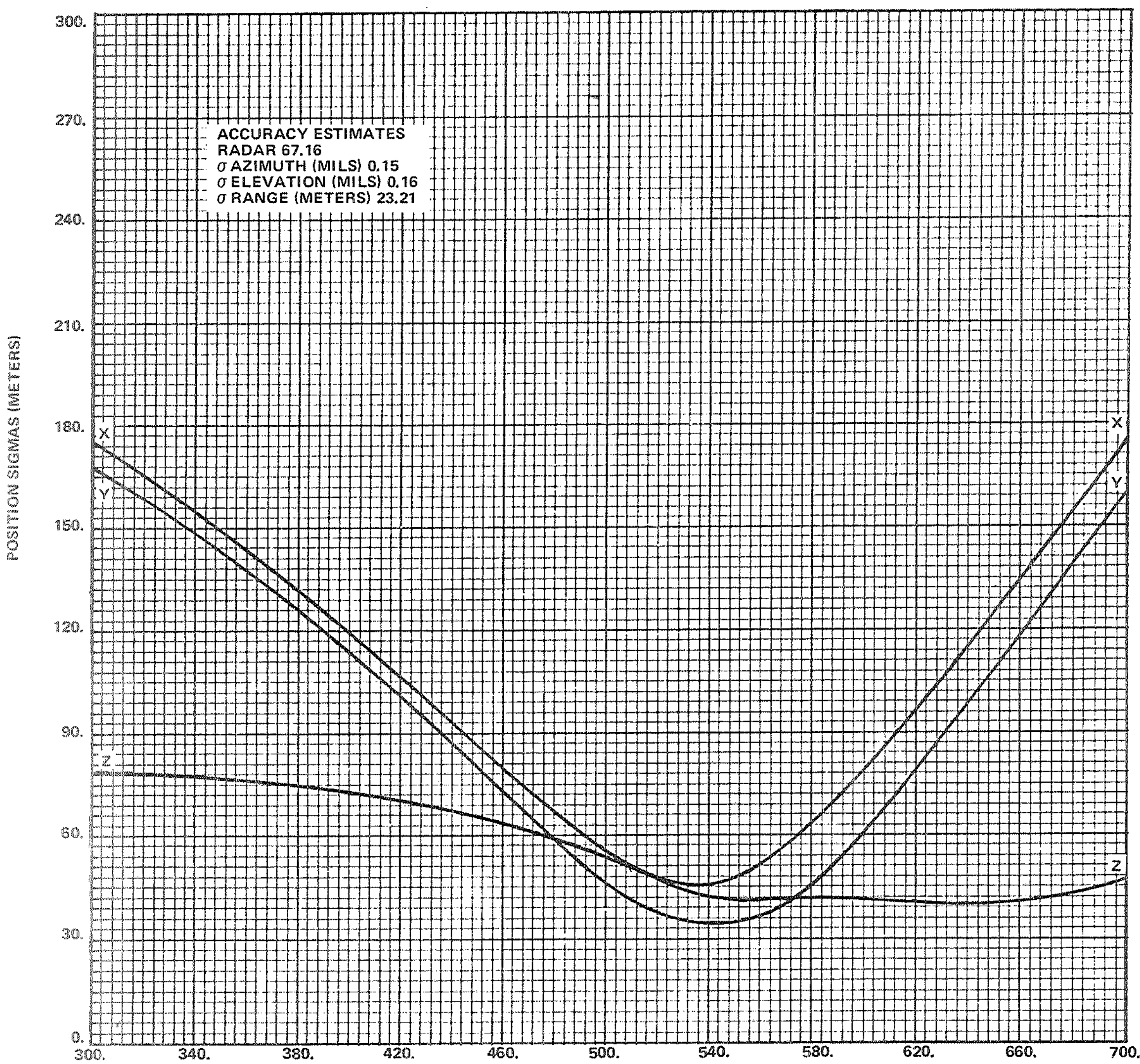


FIGURE 4-20. ESTIMATES OF BERMUDA C-BAND RADAR 67.16 POSITION ACCURACIES, AS-510 (F.A. 80°)

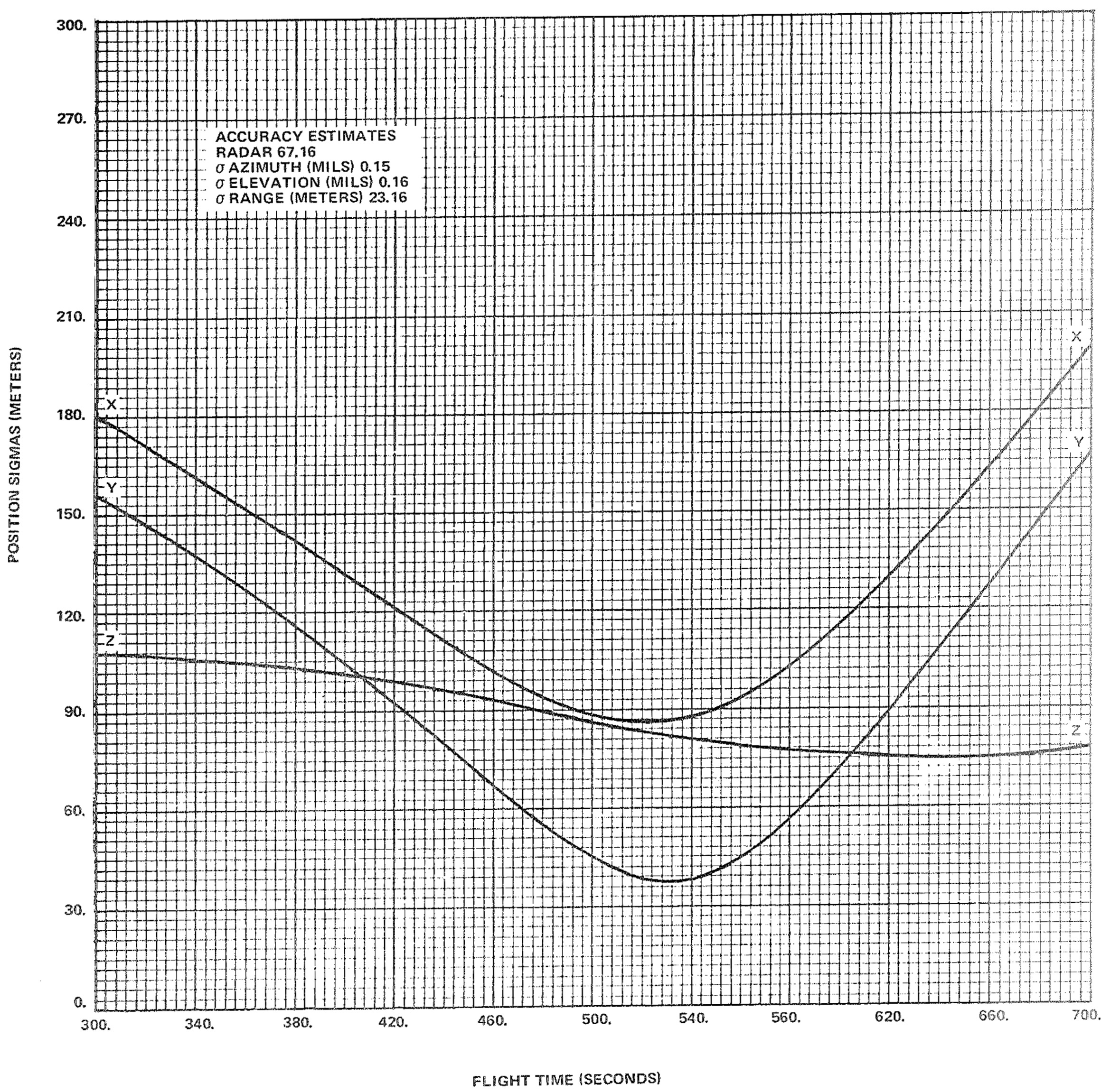


FIGURE 4-21. ESTIMATES OF BERMUDA C-BAND RADAR 67.16 POSITION ACCURACIES, AS-510 (F.A. 90°)

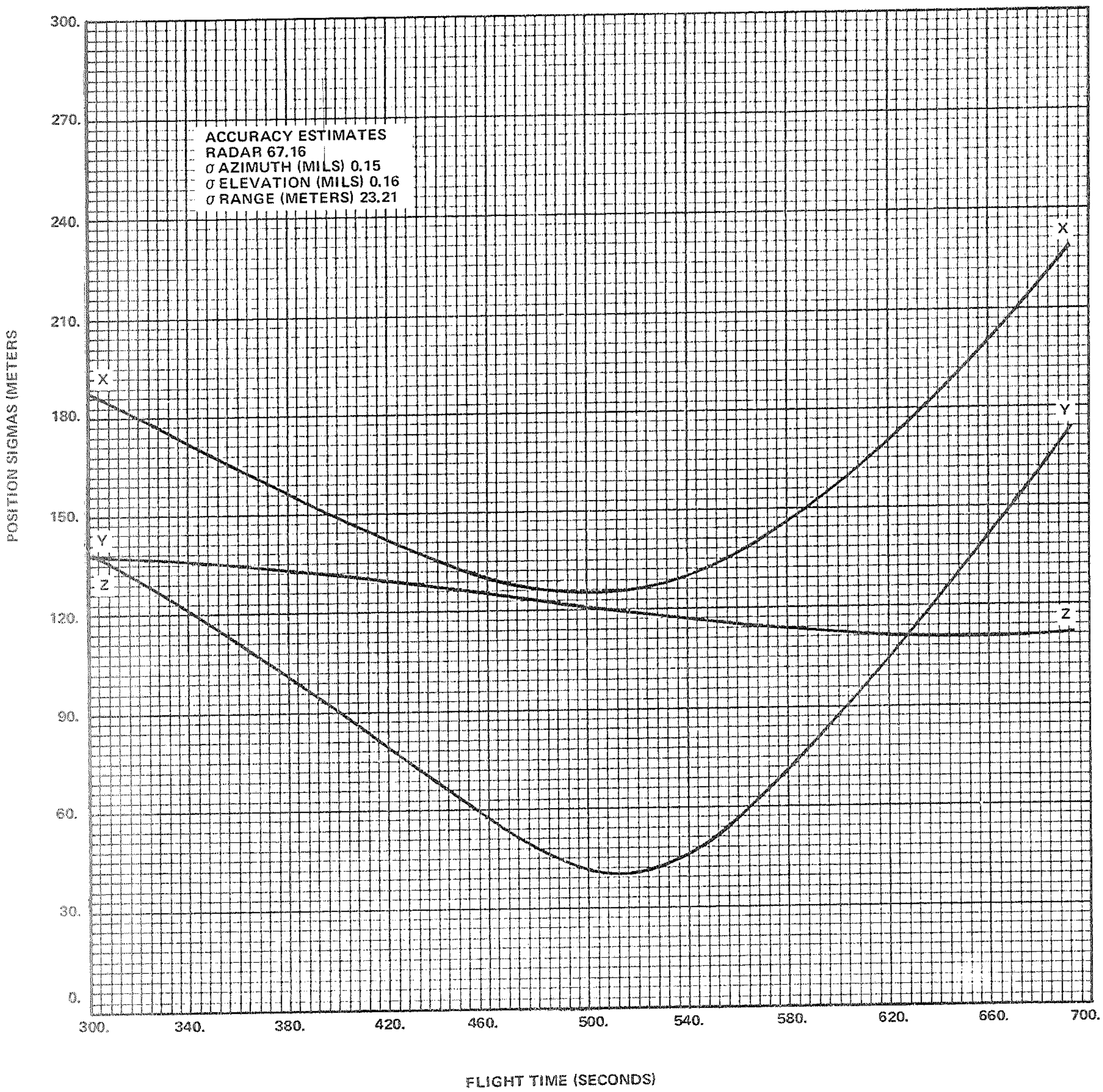


FIGURE 4-22. ESTIMATES OF BERMUDA C-BAND RADAR 67.16 POSITION ACCURACIES, AS-510 (F.A. 100°)

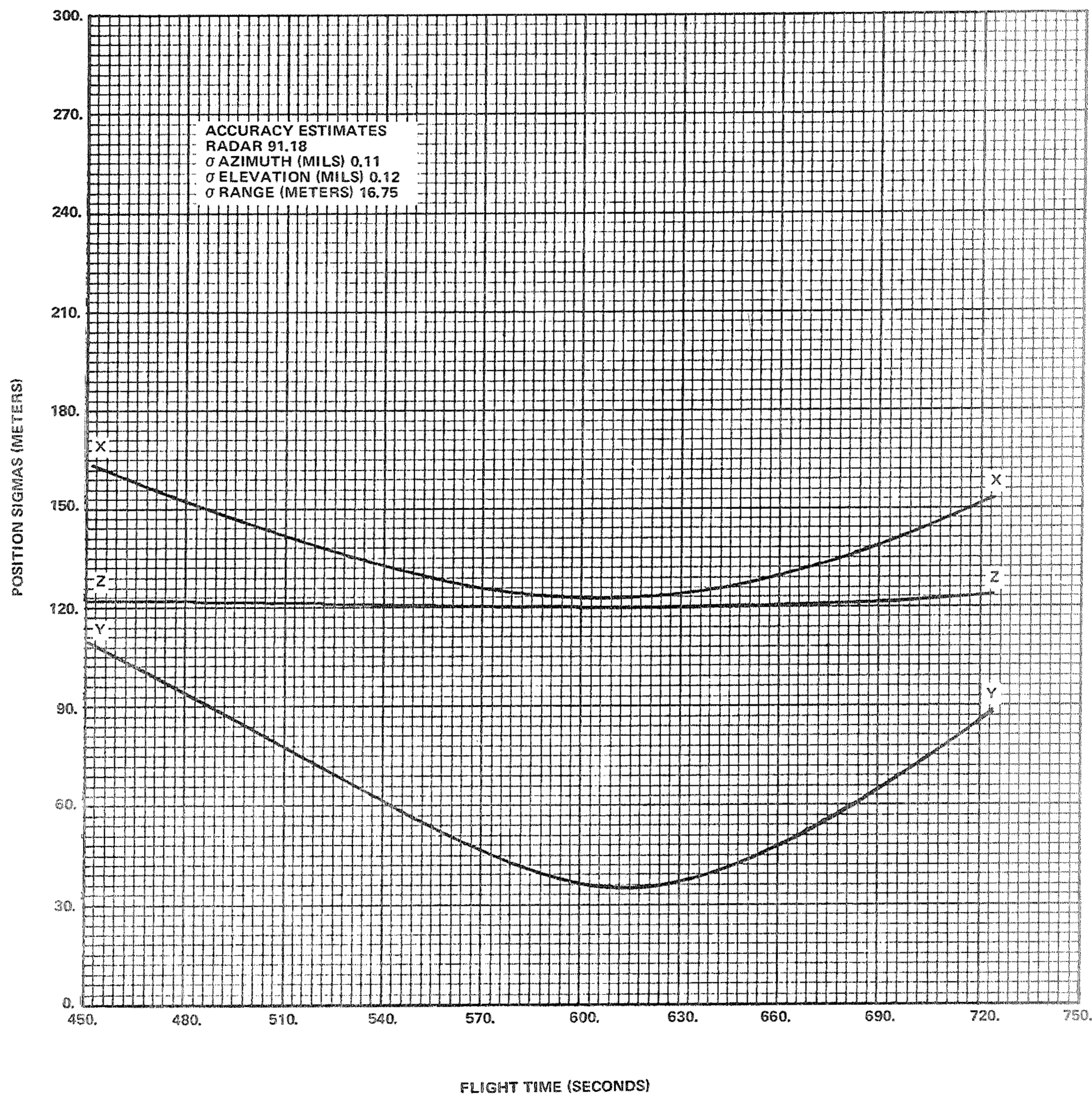


FIGURE 4-23. ESTIMATES OF ANTIGUA C-BAND RADAR 91.18 POSITION ACCURACIES, AS-510 (F.A. 90°)

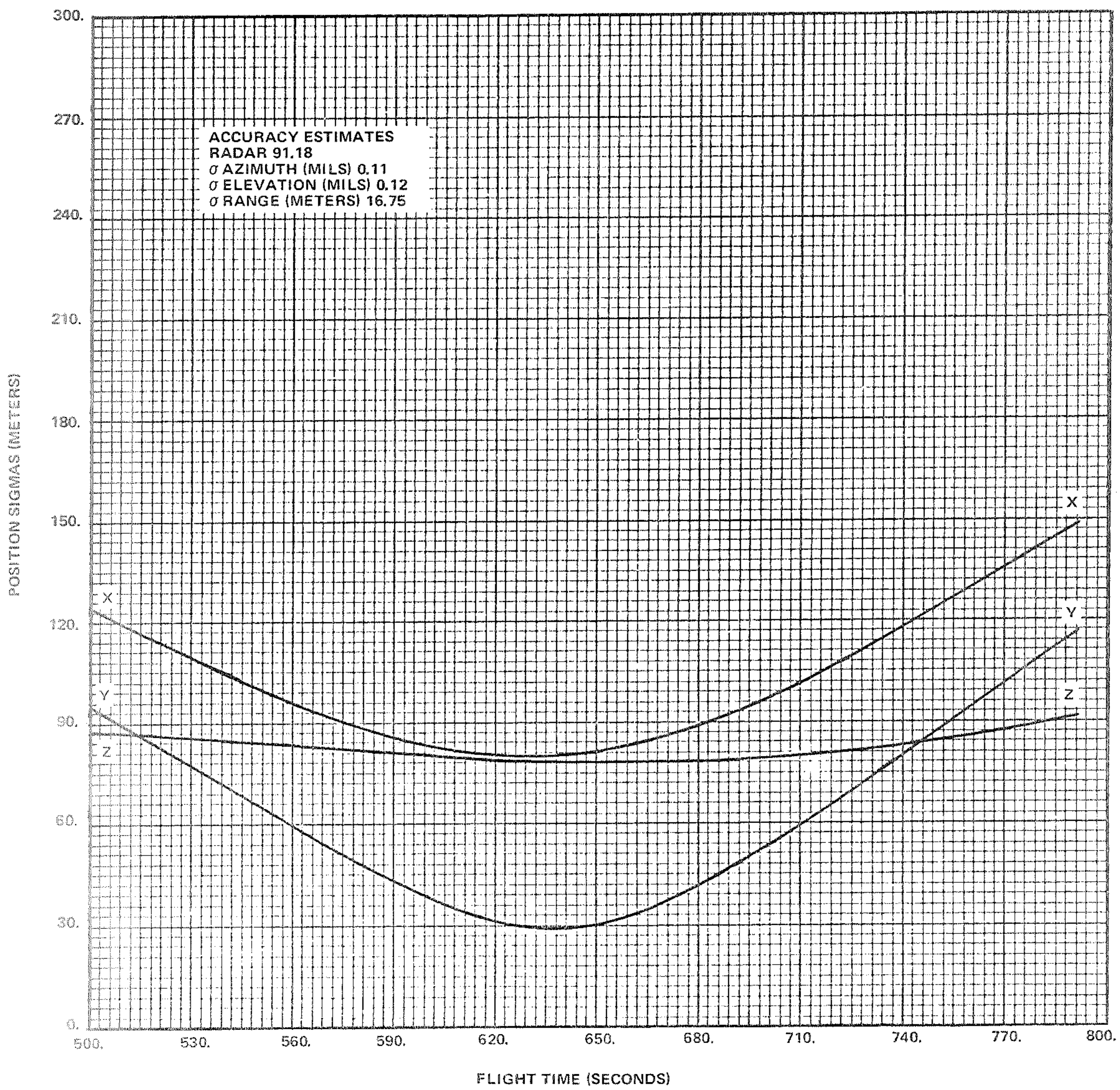


FIGURE 4-24. ESTIMATES OF ANTIGUA C-BAND RADAR 91.18 POSITION ACCURACIES, AS-510 (F.A. 100^{o})

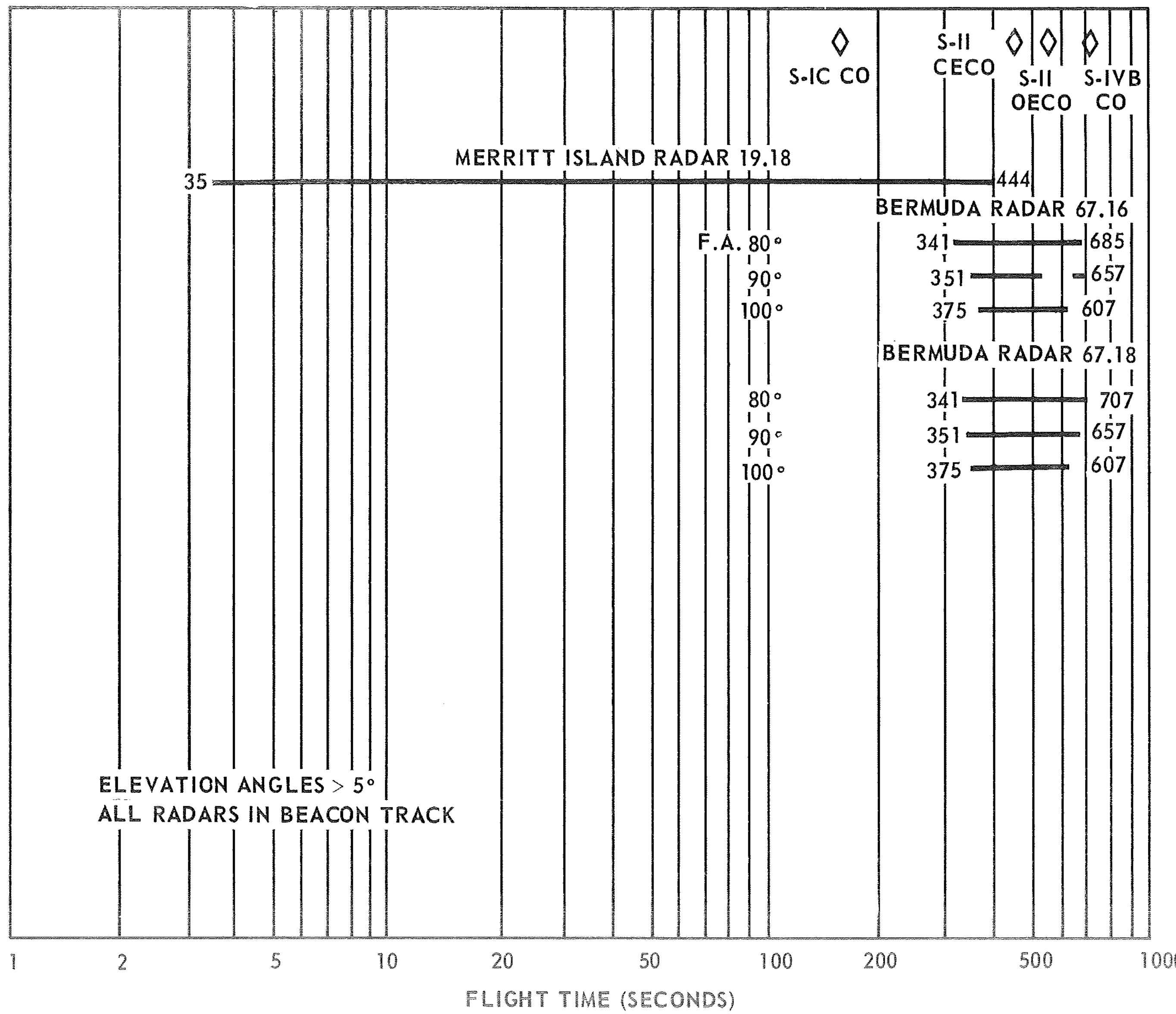


Figure 4-25. Metric Data Instrumentation Coverage for AS-510

SECTION V
ENVIRONMENTAL DATA SUPPORT

5.1 METEOROLOGICAL FORECASTS

5.1.1 LAUNCH AREA WEATHER WARNING SERVICES. The AFETR Staff Meteorologist (WE) will provide weather warning services when surface winds in excess of a specified level (36 knots approximately) are forecast or when electrical storm activity is forecast within 5 nautical miles of the launch complex. Twenty-four-hour surface and upper wind forecasts will be provided upon request. The WE will provide diffusion forecasts for the launch area as requested by the RSO.

From F-5 days to T-0, an Assistant Staff Meteorologist will be available to provide continuous advisory service, including lightning and atmospheric electrical activities. The CPS-9 radar will be used to survey the CKAFS-KSC area for severe weather conditions.

5.1.2 PRELAUNCH FORECASTS. Weather forecasts of both surface and upper-air conditions will be provided by Space-flight Meteorology Group (SMG) and WE. Forecasts valid from F-3 days or longer periods through T-0 will be provided.

5.1.3 WEATHER BRIEFING. SMG will present a weather briefing at the LCC at T-24 hours and at T-12 hours.

5.2 ENVIRONMENTAL OBSERVATIONS

5.2.1 SURFACE ENVIRONMENTAL OBSERVATIONS

5.2.1.1 AFETR Meteorological Observations. Automatic remote meteorological sensors are used for surface measurements. ETR operates eight weather tower stations on Cape Kennedy (six 54-foot and two 204-foot) and eight at KSC (seven 54-foot and one 500-foot). Surface measurements are transmitted to WINDS at Central Control and used in a Packard-Bell 250 computer to compute other parameters. The data are distributed via teletype at 30 or 15-minute intervals, except during prime test time when distribution is made at 5-minute intervals.

5.2.1.2 KSC Meteorological Observations

5.2.1.2.1 Launch Complex Wind Measuring and Recording System. The wind measuring system located at LC-39 consists of anemometers mounted on the umbilical tower and on two poles located near the launch pad. Wind speed and direction data are displayed and recorded in the Launch Control Center and are transmitted in real time to the Meteorological Prediction Center (MPC) in the MSOB and to MSFC via LIEF.

5.2.1.2.2 NASA 150-Meter Meteorological Tower. The facility provides wind speed and direction to the Air Force WINDS at the Cape and to the MPC at the MSOB. Starting at L-30 hours, the tower is continuously manned for verbal readout to MSFC and others as required. The facility provides a comprehensive data collection capability for essential lower-altitude atmospheric studies.

5.2.1.2.3 Ground-Based Lightning Warning System. The lightning warning net consists of 8 remote sites. Each site is equipped with potential gradient and corona current measuring instrumentation. The measurements will be displayed in the MPC. Two sferics sites (one at HRT site 19.1 and one at the MSOB) will use radio direction-finding techniques to detect lightning strokes. Data from the sferics sites will be transmitted to the MPC.

5.2.1.2.4 NASA-6 Geophysical Measuring System (Airborne). The NASA-6 aircraft (Twin Beech) is equipped with electric field measuring devices. The aircraft, under control of the KSC Meteorologist, gathers real-time weather and cloud electrification data during launch operations. Data are relayed to the MPC.

5.2.1.2.5 Lightning Detection Systems. The instrumentation on the umbilical tower includes: Stroke counter, stroke current amplitude (2), and corona current measuring instrumentation. The data display of the above instrumentation is in the LCC.

5.2.1.3 <u>KSC Environmental Measurements</u>

5.2.1.3.1 Acoustic Data. The acoustic data acquisition system is designed to measure the acoustic environment produced by large launch vehicles. Simultaneous near-field and far-field measurements of sound-pressure levels and frequencies are recorded for analysis in the wave analysis laboratory in the CIF.

a. Near-Field Measurements - Measurements in the pad area are indicated on Figure 4-1.

b. Far-Field Measurements - Portable equipment will be used to measure and record data at approximately nine sites located several miles from the launch pad.

5.2.1.3.2 Blast Gauges. BRL blast gauges will be installed and operated in the pad area. The data will be reduced only in case of an explosion.

5.2.1.3.3 Facilities and Environmental Measurements. Approximately 450 measurements located in the LC are monitored and/or recorded during prelaunch checkout and launch to evaluate the facility performance and to determine the effect of the launch vehicle on its environment.

5.2.2 UPPER AIR METEOROLOGICAL OBSERVATIONS

5.2.2.1 Meteorological Balloon Data. Jimsphere balloons, released periodically throughout the countdown, are tracked by radar (see Section 4.1.1.2) through altitudes of approximately 60,000 feet. The data are transmitted to MSFC and MSC (see Sections 6.2.3 and 6.2.6). These data are processed by an MSC/MSFC team to determine if the wind environment is suitable for launch. The results of the evaluation will be provided to KSC via LIEF.

5.2.2.2 Upper Air Soundings. AFETR will provide upper air data obtained by the RS system, sonde equipment launched by rockets, and by WS equipment.

5.2.3 WEATHER AIRCRAFT. An ETR aircraft carrying an observer will provide launch area reconnaissance from approximately T-2 hours through launch.

SECTION VI
SPACE VEHICLE DATA HANDLING

6.1 AFETR REAL-TIME DATA PROCESSING SYSTEMS

6.1.1 REAL-TIME COMPUTER SYSTEM (RTCS). Real-time tracking data from the C-band radars are processed in the CDC 3600 computer to generate range safety data and to satisfy real-time data requirements. All input tracking data are processed to determine the best data source which is then used to compute present position and velocity, instantaneous impact point, and acquisition data. RTCS output will be as follows:

a. Primary IP data to CADDAC for Range Safety plotting board display.

b. Present-position data to CADDAC for Range Safety and LCC plotting board display.

c. Reduced data and raw and smoothed radar measured parameters to the LTDS (see Section 6.1.2) for routing to the CIF, MCC-H, GSFC, and USB.

d. Acquisition data for use by various instrumentation sites.

The RTCS will also provide alternate IP data to CADDAC for Range Safety display from the second best data source.

Data from radar 19.18 will be reformatted into the standard 38-character TTY format by AN/UYK computers at the site and transmitted to the RTCS. At the RTCS, this data will be patched through to GSFC in real/near-real time.

IU guidance data from the CIF TLM station, and SC guidance data from the KSC USB site will be transmitted to the RTCS via ALDS for Range Safety and/or launch recovery application. The ETR TLM station TEL IV will provide analogue and discrete launch vehicle parameters (other than guidance) which are then transmitted through the RTCS for Range Safety application.

6.1.2 LAUNCH TRAJECTORY DATA SYSTEMS (LTDS). Tracking data will be routed from the RTCS to MCC-H, GSFC, and the CIF Data-Core via two Digital Control Units (DCU). Present position and velocity data will be provided.

6.2 KSC REAL-TIME DATA PROCESSING SYSTEMS

6.2.1 CIF DATA-CORE. The Data-Core is basically an electronic system that receives various analog and digital input data from a number of asynchronous sources and processes these data into a common 26-bit digital format for direct use by high-speed digital computers, data transmission equipment, and quick-look data display devices. The Data-Core will receive data from the following sources: CIF Ground Station, CIF Antenna Field VHF and S-band TLM receivers, Apollo simulators, LTDS, CCATS (selected TLM parameters from Houston), DDAS, and the MILA USB Station (S-band and VHF).

The Data-Core provides data to the following points: ALDS, LIEF, Central Computer Facility, CIF Operational Support Center, CIF Ground Station (selected parameters for display), MSOB ACE Station (Spacecraft data for display), DDAS (LV data for display after LOS by DDAS at T-0), and MILA USB (unprocessed video signal).

6.2.2 TELEVISION DATA DISPLAY SYSTEM. Launch Vehicle and/or Facility data are displayed in the Firing Room (LCC) at ten monitor positions. Out-of-tolerance data as detected by the Central Computer are displayed on one of the two adjacent CRT's at the monitoring position. An audible alarm feature is also provided.

6.2.3 METEOROLOGICAL REAL-TIME SYSTEM (MRTS). Raw data from the AFETR radar assigned to track the Metro. balloon (see Section 4.1.1.2) will be received in real time, during the balloon ascent (for approximately one hour for each run), at the CIF. The data will be recorded in digital format and delivered to the KSC Central Computer Facility at the conclusion of the balloon track. The measured radar parameters will also be transmitted to MSFC in real time via the LIEF system.

6.2.4 KSC CENTRAL COMPUTER FACILITY. The Central Computer Facility receives TLM (up to 3000 measurements) and tracking data from the Data-Core. It converts the TLM data to engineering units for display or storage. The system records raw TLM (up to 5000 measurements) and tracking data for off-line launch analysis.

6.2.4.1 Data Distribution. The real-time data are displayed on CRT's, Eidophor screens, recorders, or printed out locally in the CIF, in the Firing Room, and other operational rooms of LC-39.

6.2.4.2 Launch Vehicle Guidance Data. Launch vehicle guidance checkout data from the Data-Core are processed in a guidance reduction program (LVDC/LVDA) several times during the countdown to provide launch critical data.

6.2.4.3 Launch Vehicle Strain Gauge Data. The data are accepted by the Data-Core after Mobile Service Structure (MSS) rollback. The GE-635 computer calculates vehicle bending moments during possible adverse fuel loading - wind velocity conditions for immediate evaluation by LV personnel.

6.2.4.4 Trajectory Data Reduction. The GE-635 accepts real-time trajectory data from the RTCS via the Data-Core and provides data for a dynamic display of vehicle flight and comparison to the nominal trajectory.

6.2.4.5 Radar-Balloon Determined Wind Reduction. The METS in the CIF records radar tracked balloon data. The data are processed in near-real time to determine wind velocity and direction vs. altitude. These data are transmitted to MSFC via the LIEF tape-to-tape transceiver. Reduced data from selected balloon releases are also transmitted to MSC via a tape-to-tape and a card-to-card transceiver.

6.2.4.6 Atmospheric Transport Program. The GE-635 accepts data relating to wind speed and direction/temperature vs. altitude and calculates downwind air and ground concentration of particulates or gaseous material.

6.2.5 APOLLO LAUNCH DATA SYSTEMS. The ALDS receives TLM data from the Data-Core and transmits selected TLM parameters to MCC-H at the rate of 40.8 kbs and to GSFC and the RTCS at the rate of 2.4 kbs. (See Section 6.2.1)

6.2.6 LAUNCH INFORMATION EXCHANGE FACILITY. The LIEF network contains, in addition to a number of voice circuits, the following data circuits:

a. A 40.8 kbs data circuit and a 2.4 kbs data request circuit. MSFC is supplied selected real-time telemetry and/or tracking data via the 40.8 kbs circuit. Parameter selection is controlled by MSFC via the 2.4 kbs data circuit. (See Section 6.2.1)

b. One OTV Circuit. Any one of the OTV cameras (see Section 4.2.3.3.2) may be monitored at MSFC. Camera selection is controlled by MSFC by verbal request.

c. One Countdown Clock Circuit.

d. One Tape-to-Tape Circuit.

e. One Facsimile Circuit.

6.3 AFETR POST-EVENT DATA HANDLING

All AFETR data are released to the KSC Data Office.

6.4 KSC POST-TEST DATA HANDLING

KSC post-test data handling and disposition are described in the Data Disposition Document.

6.4.1 KSC POSTLAUNCH DATA DISPLAY ROOMS. All requested data for evaluation generated during the launch phase of Mission 510 will be displayed in the data display rooms as soon as the data become available. This service is provided to make the data available to all interested parties in the shortest possible time. Post-test records will consist of analog strip chart records, 4020 plots, oscillograph recordings, etc. Spacecraft data will be displayed in rooms 2296 and 2299 of the MSOB. Launch vehicle data will be displayed in rooms 2R7 and 2R9 of LC-39.

SECTION VII
FLIGHT SAFETY INSTRUMENTATION

7.1 RANGE SAFETY INSTRUMENTATION

7.1.1 COMMAND/CONTROL SYSTEMS. The Range Safety Command/Control transmitters which may be used to transmit commands to the SRS Destruct System (see Section 3.5.1) are listed below:

Station No.	Station Name	Transmitter
1	CKAFS	Low Power
1	CKAFS	High Power
3	GBI	High Power
7	Grand Turk	High Power
67	Bermuda	High Power
91	Antigua	High Power

7.1.2 IMPACT PREDICTION. Plots of the instantaneous impact point and present position are generated by the RTCS (see Section 6.1.1) for use by the RSO.

7.1.3 SKYSCREENS

7.1.3.1 TV Skyscreens. Video monitors will display images from the Range Safety video skyscreens (see Section 4.2.3) for use by the RSO. A Flightline and Program system is provided.

7.1.3.2 Wire Skyscreen. Wire skyscreen 1.7 will be used to provide program deviation.

7.1.4 SELECTED TLM PARAMETERS. Selected TLM parameters from the IU and SC guidance systems are used for computation of instantaneous impact points. ETR Stations 19 (TEL IV) and 91 (Antigua) provide Launch Vehicle parameters for range safety decision (see Section 6.1.1.d).

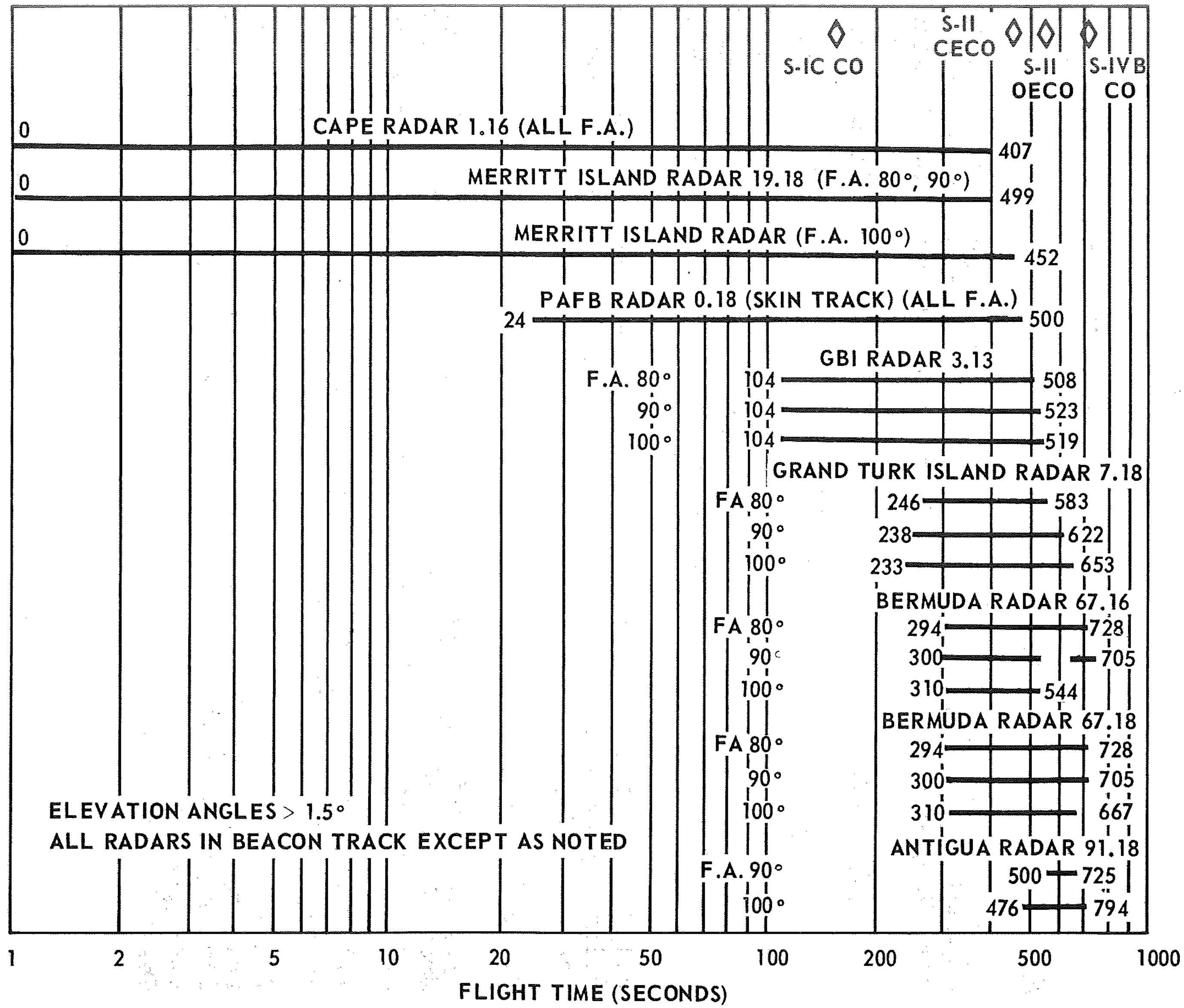


Figure 7-1. Range Safety Instrumentation Coverage for AS-510

7.1.5 SURVEILLANCE RADARS

7.1.5.1 Range Surveillance Radars. MOD II Radar 1.5 and Radar 1.35, located at Central Control, will provide sea surveillance. The SPS-35 will provide additional range surveillance.

7.1.6 SURVEILLANCE AIRCRAFT. One helicopter will perform launch area sea surveillance.

7.1.7 SURVEILLANCE BOAT. One Port Canaveral Coast Guard boat will monitor the launch danger area.

7.1.8 RANGE SAFETY INSTRUMENTATION SUMMARY. The estimates of instrumentation flight time coverage which are expected for Range Safety are summarized in Figure 7-1.

7.2 PAD SAFETY INSTRUMENTATION

7.2.1 HYDROGEN HAZARDS MONITORING SYSTEM

7.2.1.1 Hydrogen Leak Detection Systems

7.2.1.1.1 Fixed System. Sensor heads are located at predetermined points to monitor critical areas for the presence of H_2.

7.2.1.1.2 Portable Systems. Each detector consists of a probe connected to an instrument box by a 6-foot cable. The detectors are used by launch personnel to investigate suspicious areas.

7.2.1.2 Hydrogen Fire Detection Systems

7.2.1.2.1 Thermal Wire (TW) System. The TW detection element is a cable which may be wrapped around a potential leakage point to monitor the temperature for indication of H_2 fire.

7.2.1.2.2 Ultraviolet (UV) System. The UV sensors are located at predetermined points to detect the UV radiation of hydrogen flames.

7.2.2 HYPERGOLIC HAZARDS MONITORING SYSTEM. Portable vapor detectors, designed to detect and monitor the concentration of toxic propellant vapors in the atmosphere, display the fuel (aerozine 50) and oxidizer (nitrogen tetroxide) vapor levels on separate meters. Aural and visual alarms are generated when the detected levels of these propellants exceed previously selected limits.

7.3 ABORT-EGRESS ADVISORY SYSTEM

An egress or abort request may be issued to the flight crew from the Launch Operation Manager's console. The console is equipped with two TV monitors to monitor the abort system TV cameras (see Section 4.2.3.3.1) and with status lights designed to alert the operator to impending catastrophic conditions. Observers will advise the console operator of unusual indications of hazardous or catastrophic conditions.

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